Novus 4525 Scientist PR

Operations Guide

Made in America, with pride, by National Semiconductor

All the advanced electronics in this Novus calculator are manufactured by National Semiconductor Corporation, a world leader in the design and production solid-state electronic components. National is a multinational, NYSE-listed company that's demonstrated unparalleled growth over the last six years.

Your Novus calculator is built in the USA. That's because American technology—and specifically the know-how of National Semiconductor—is the key to this product's quality, reliability and computation "horsepower." No other manufacturer can equal National's ability to produce rugged, performance-packed components in the large volumes that result in quality products with small price tags.

The same National Semiconductor electronics have helped take Americans to the moon and back, and are the critical "guts" of high-performance products ranging from life-saving medical equipment to consumer products such as color tv's and digital watches.

You now own one of the world's most technically-advanced consumer products. We hope you'll be as proud to use it as we were to make it.

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Getting Started

Turn your Novus Scientist on with the switch on the left side of the calculator. The calculator is automatically cleared and the display should now show 0. If it does not, check to see if the battery needs recharging by connecting the Novus AC charger.

AC Charger

Your Novus Scientist is powered by rechargeable batteries. A dot will illuminate (•) on the extreme left side of the display as a low-battery indicator. Although calculations can still be made while the low-battery indicator is on, the battery should be charged as soon as possible. Continued use on a weak battery may result in inaccurate answers. To charge the batteries connect the Novus AC Charger to the jack on the top left side of the machine. A typical full charge takes five hours. You can operate your calculator while the charger is connected. BE SURE THE CALCULATOR IS TURNED OFF BEFORE CONNECTING THE AC CHARGER.

Operation

Display

The Novus Scientist displays an 8-digit mantissa and a 2-digit exponent. The calculator will accept and display any positive or negative number between -1×10^{-99} and 9.9999999×10^{99}. Any result larger than 9.9999999×10^{99} will result in an overflow indicated by displaying 8 mantissa digits of the result with the two least significant digits of the 3-digit exponent. Computed results between the range of 0.1 and 99999999 are displayed in floating point format. Results smaller than 0.1 or larger than 99999999 are automatically converted to scientific notation format.

Automatic Display Shutoff

To save battery life, the Novus Scientist shuts off all but the most significant digit of the mantissa if no key has been pressed for approximately 30 seconds. No data has changed and to restore the display without changing its contents, touch CHS twice.

Reverse Polish Logic and the Stack Principle

The Novus Scientist uses Reverse Polish logic with four registers called X, Y, Z and T. A register is an electronic element used to store data while it is being displayed, processed or waiting to be processed. The four registers are arranged in a "stack" as follows: (To avoid confusion between the name of a register and its contents, the registers in this diagram and the diagrams in Appendix A are represented by capital letters X, Y, Z and T and the contents of the registers by lower case letters x, y, z and t).

CONTENTS	LOCATION
t	T
z	Z
y	Y
x	X

The display always shows the contents (x) of register X. See Appendix A for diagrams showing what happens to the stack for each operation of the Novus Scientist.

Keying In and Entering Numbers

To enter the first number in a 2-function calculation, key in the number and touch ENT. If your number includes a decimal point, key it in with the number. If a decimal is keyed in more than once in a number entry, the calculator will use the last decimal keyed in. You do not have to key in the decimal in whole numbers.

To enter a negative number, key in the number and touch CHS.

Scientific Notation

Any number can be entered into the Novus Scientist in scientific notation—that is, as a number (mantissa) multiplied by 10 raised to a power (exponent). The exponent indicates how many places the decimal point should be moved. If the exponent is positive, the decimal is moved to the right. If the exponent is negative, the decimal is moved to the left. For example: 1200 can be entered as 1.2×10^3. Key in: 1.2 EE 3, the display shows: 1.2 03. Note: The last two digits on the right side of the display are used to indicate exponents.

Very large and very small numbers must be entered in scientific notation. For example: 134,000,000,000,000 (written 1.34×10^{14}) must be keyed in: 1.34 EE 14; display shows: 1.34 14. To enter a negative exponent, touch CHS after keying in the exponent. Example: .000000000034 (written 3.4×10^{-11}) must be keyed in: 3.4 EE 11 CHS, display shows: 3.4 –11.

If EE has not been preceded by a mantissa entry, the EE depression is ignored.

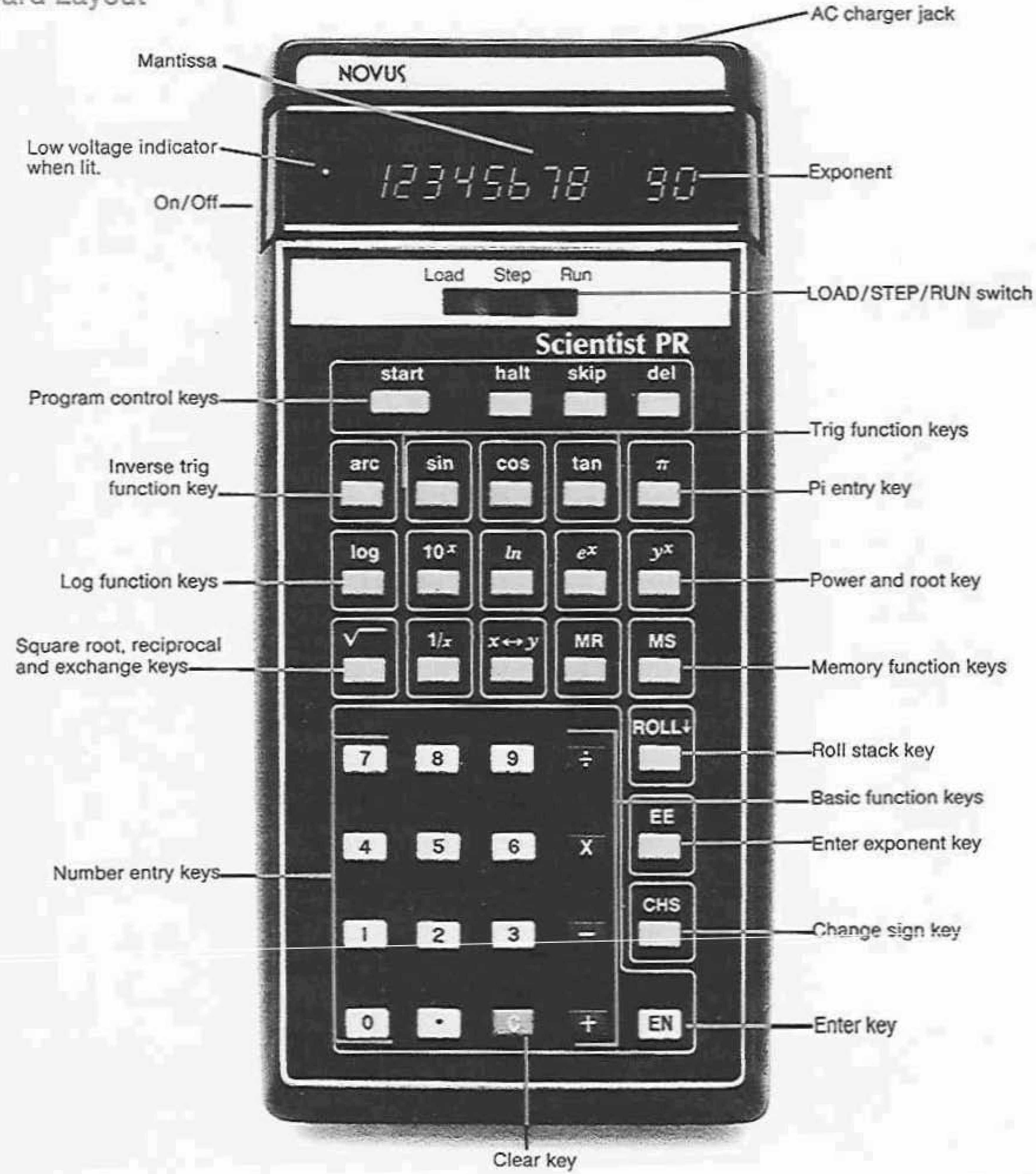
Correcting Mistakes

To clear a wrong number entry, touch C. Touching C clears the X register (display) and drops the stack down.

To correct a wrong exponent entry, just key in the correct exponent. If more than two numbers are keyed in after touching EE, the calculator retains the last two numbers keyed in as the exponent.

To correct a wrong mantissa entry after EE has been touched, touch • (decimal). This will clear the display to 0 and allow re-entry of the mantissa and exponent.

Keyboard Layout



Keyboard Callouts

arc Touched before sin, cos or tan computes the inverse sine, cosine or tangent (in degrees), respectively, of the number in the display.

sin Computes the sine of the angle (in degrees) in the display.

cos Computes the cosine of the angle (in degrees) in the display.

tan Computes the tangent of the angle (in degrees) in the display.

π Enters Pi (π) = 3.1415927 into the display (X register), and raises stack.

log Computes the common logarithm of the number in the display.

10^x Computes the common antilogarithm of the number in the display. (Raises 10 to 'x' power).

ln Computes the natural logarithm of the number in the display.

e^x Computes the natural antilogarithm of the number in the display. (Raises e = 2.7182812 to the 'x' power).

y^x Raises 'y' to the 'x' power.

$\sqrt{\ }$ Computes the square root of the number in the display.

1/x Computes the reciprocal of the number in the display. (Divides 1 by 'x').

x↔y Exchanges the number now in the display with the number last in the display.

MR Recalls the contents of memory to the display (X register), and raises stack.

MS Stores the number in the display in memory.

ROLL Moves the contents of register X to register T, the contents of register Y to register X, the contents of register Z to register Y and the contents of register T to register Z.

EE Instructs the calculator to accept the next number keyed in as an exponent of 10.

CHS Changes the sign of the number in the display.

ENT Enters the number in the display (x register) into a working register (y register).

÷ Divides 'y' by 'x'.

× Multiplies 'y' by 'x'.

− Subtracts 'x' from 'y'.

+ Adds 'x' to 'y'.

C Clears contents of display (x register) and rolls stack down.

See page 8 for explanation of program control keys.

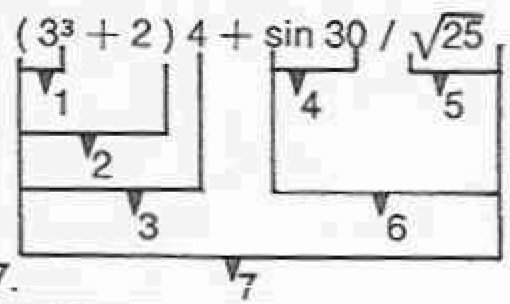
In addition to the separate memory, there are four locations where numbers can be kept for operations. These locations are called registers and in the Scientist these have been combined into an automatic stack. The Novus Scientist uses the four-level stack along with Reverse Polish logic to allow calculations according to mathematical hierarchy.

Mathematical Hierarchy and Reverse Polish Logic

Hierarchy is a term for the rules of mathematics referring to the order of performance of operations on numbers. Those rules are:

1. Do the problem left to right.
2. Do all operations within parentheses, if any, first.
3. Perform operations in the following order:
   a. raising to powers, taking roots, trig, log and reciprocal functions,
   b. multiplication and division,
   c. addition and subtraction.
4. Repeat steps 1 through 3 until the calculation is complete.

Example: The equation $(3^3 + 2)4 + \sin 30/\sqrt{25} = 116.1$ is solved according to the rules of hierarchy as follows:



1. $3^3 = 27.$
2. $2 + 27 = 29.$
3. $29 \times 4 = 116.$
4. $\sin 30 = .5$
5. $\sqrt{25} = 5.$
6. $.5 \div 5 = .1$
7. $116 + .1 = 116.1$

1. Starting at the left and working right, key in the next number (or the first if this is the beginning of a new problem).
2. Ask yourself: "Can an operation be performed according to the rules of hierarchy?" If so, perform all operations possible. If not, touch ENT.
3. Repeat steps 1 and 2 until your calculation is complete.

Following these three steps, you can calculate the example equation $(3^3 + 2)4 + \sin 30 / \sqrt{25}$ using Reverse Polish logic as follows:

KEY IN	DISPLAY SHOWS	COMMENTS
3	3	
ENT	3.	
3	3	
y^x	26.999981*	3^3
2	2	
+	28.999981	$(3^3 + 2)$
4	4	
×	115.99992	$(3^3 + 2)4$
30	30	
sin	0.5000002	sin 30
25	25	
√	5	$\sqrt{25.}$
÷	0.1	$.5 \div 5$
+	116.09992	$(3^3 + 2)4 + \sin 30/\sqrt{25.}$

Calculation is complete and performed according to the rules of hierarchy.

*Note: The actual results which occur when performing special functions must be rounded off to the third to sixth place for greater accuracy. The inaccuracy (e.g. $3^3 = 26.999981$ instead of 27) of answers occurs because extra guard digits and rounding techniques are not employed during calculations in order to simplify the technical design of your calculator.

One-Factor Calculations

The one-factor functions are listed below. These function keys operate on the displayed entry or result, that is, the indicated trig, log or other special operation is performed automatically when you depress one of these keys:

Examples:

Sin 30° = 0.5
Key in: 30 sin ; display shows 0.5000002

Cos -1 0.5 = 60
Key in: .5 arc cos ; display shows 60.000454

√ Computes the square root of the number in the display.

1/x Computes the reciprocal of the number in the display.
Example: Key in: 2 1/x ; display shows: 0.5.

ln Computes the natural logarithm of any positive number in the display.

e^x Computes the natural antilog of the number in the display by raising 'e' (2.7182812) to the power in the display.

log Computes the common logarithm of any positive number in the display.

10^x Computes the common antilog of the number in the display by raising 10 to the power in the display.

sin Computes the sine of the angle (in degrees) in the display.

cos Computes the cosine of the angle (in degrees) in the display.

tan Computes the tangent of the angle (in degrees) in the display.

arc Touched before sin , cos , or tan , computes the arc sine, arc cosine or arc tangent (in degrees), respectively, of the number in the display.

Two-Factor Calculations

Functions involving more than one variable are performed by keying in the first factor and depressing ENT , keying in the second factor and depressing × for multiplication, ÷ for division, y^x for raising y (value entered on ENT) to the power keyed in as the second entry.

Examples:

15 − 3 = 12
Key in: 15 ENT 3 − ; display shows 12

12 + 4 = 16
Key in: 12 ENT 4 + ; display shows 16

10 ÷ 2 = 5
Key in: 10 ENT 5 ÷ ; display shows 5

6 × 5 = 30
Key in: 6 ENT 5 × ; display shows 30

$4^3 = 64$
Key in: 4 ENT 3 y^x ; display shows 64.000033*

*See note, page 6.

Chain Calculations

The stack automatically lifts calculated answers when you complete a calculation and drops during calculations involving both the X and Y registers as illustrated on page 20-22. This automatic stack lift and drop allows you to retain intermediate results without re-entering numbers. Many calculations can be approached by keying in numbers in left to right order.

Example:

(2 + 3) × (4 + 5) = 45
Key in: 2 ENT 3 + 4 ENT 5 + ×

Memory

MS Stores the number in the display in memory (register M).

MR Recalls the contents of memory (register M) to the display (register X).

To clear memory, key in: 0 MS .

The addition of "learn mode" programming to the already powerful Novus Scientist provides the user with a unique time saving approach to the evaluation of long equations or those which require iterative solutions.

"Learn-mode" programming is essentially automatic key pressing. One of the benefits of the "learn-mode" programmer is its inherent simplicity in developing and using a program. Effective use of the programmer does not require any special skills or knowledge of programming languages. If you can use the calculator, you can use the programmer!

The basic technique of "learn-mode" programming is that the programmer remembers the sequence of key depressions used to solve a problem. Therefore, to program the calculator, all the user must do is solve the problem correctly once with the programmer in LOAD mode. Even if mistakes are made, when the proper corrections are made the programmer will learn the corrections and yield the proper solution.

Programming Function Keys

LOAD/STEP/RUN Switch

LOAD—Allows loading of program steps into the program storage area.

STEP—Executes one step of a stored program for each touch of start.

RUN—Permits execution of programs by use of the start or skip keys.

Programming Keys

start The start key has functions in both the LOAD and RUN modes.

In LOAD mode, touching start will erase all previously stored information in the program storage area, write a START code and mark the beginning of the first program. In the RUN mode, touching start begins execution of the first program. If the programmer is stopped at a HALT code (explained below), touching start continues the program to the next HALT or to the end of the program. After reaching the end of a program, the programmer always returns to the START code at the beginning of the first program.

skip The skip key has functions in both the LOAD and RUN modes. In the LOAD mode, touching skip marks the beginning of programs other than the first. It writes a SKIP code for each subsequent program. In RUN mode, touching skip causes the programmer to jump from the beginning of a program, or from a HALT point, to the beginning of the next program and begin execution of that program. Execution continues to the first HALT or to the end. If only one program is stored and the programmer is stopped at a HALT, touching skip will jump over the remaining part of the program and start execution at the beginning of the program. This feature may be used to create a "loop" within the main program. When only two programs are stored, touching skip effectively executes the second program and touching start executes the first. When more than two programs are stored, a HALT code must be programmed in somewhere in all programs except the first. To execute the second program, touch skip, to execute the third program, touch skip twice, to execute the n^{th} program, touch skip n-1 times.

halt The halt key functions only in the LOAD mode and is used to insert a HALT code in the program sequence. In RUN mode, when the programmer encounters a HALT code, it stops the play back of the program and returns control of the calculator back to the user. halt is usually used as a pause in the program execution to allow the reading of an intermediate result and/or to input a variable for further processing. Normally, start is used to leave the HALT condition and continue execution of the program, but it will also allow branching to the next or subsequent programs if skip is touched.

del The del key (delete) functions only in the LOAD mode and is used for editing the program. Its purpose is to remove entries from the program memory. Touching del always starts with the last program step entered and removes one entry each time it is touched. It is essentially a backspace key. Using the del key can cause the error alarm to come on if an attempt is made to delete a START or SKIP code. When a SKIP code is deleted, the alarm means that an entire program has been removed. Touching del again will turn off the error alarm and delete the last step of the program preceding the deleted SKIP. If the alarm does not go off with the next touch of del, it means that the START code is the only code left in the program memory and all programs have been cleared. The START code cannot be deleted. If a SKIP code is deleted accidentally, re-entering skip will reinitiate that program.

Error Alarm

The programmable Scientist has a program memory capacity of 100 steps. If more than 100 program steps are entered, or if a SKIP code is deleted, or an attempt is made to delete a START code, an error alarm consisting of all decimal points will be displayed. For example, (. 1 . 2 . 3 . 4 . 5 . . . .) would indicate an error alarm.

Entering Variables

With the LOAD/STEP/RUN switch in RUN position, when the program encounters a HALT code, control of the calculator is returned to the user. A variable can be entered for further processing at that time. A variable consists of any number entry key (0-9), CHS or π. Touching start after the variable has been entered continues the program from the HALT code.

Entering Constants

With the LOAD/STEP/RUN switch in LOAD position, keying in any number entry key (0-9), CHS or π WITHOUT preceding the number with a HALT code enters the number in the program as a constant. This constant will be automatically keyed in and used each time the program is run.

Programmer Control Operations

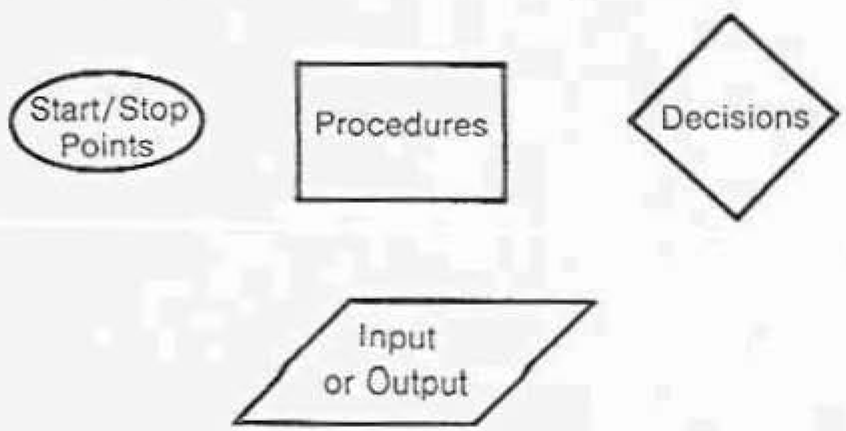
The following table summarizes the operations of the programming switch and keys.

KEY	LOAD MODE	RUN MODE
start	Clears program area and writes START code.	Starts first program or continues from a HALT.
skip	Marks beginning of programs subsequent to the first.	Jumps over remainder of a program and begins execution of the next program.
del	Deletes the last step entered in a program.	No function.
halt	Writes a HALT code in the program and returns control of calculator to user.	No function.

SWITCH	FUNCTION
RUN position	Permits execution of programs by use of start or skip.
LOAD position	Allows loading of programs into program storage area.
Switching from LOAD to RUN position	Positions programmer control to begin execution of the first program.
Switching from RUN to LOAD position	Positions programmer control to begin entering more program steps to the end of the last program entered. Previous program data is not affected. Multiple programs can be added at this point by touching skip.
Switching from RUN to LOAD to RUN position	Positions programmer control to begin execution of the first program entered. This feature can be useful if the user is interrupted during his calculations and forgets which portion of the program was last executed.
STEP position	Executes one step of a stored program for each touch of the start key.

Programming Examples

The following example programs will illustrate the versatility of the programmable Scientist. The following programming symbols will be used to help define the flow of execution of sample programs:



Input (variable or constant data key entry) or Output (displayed results)

Entering Single Programs

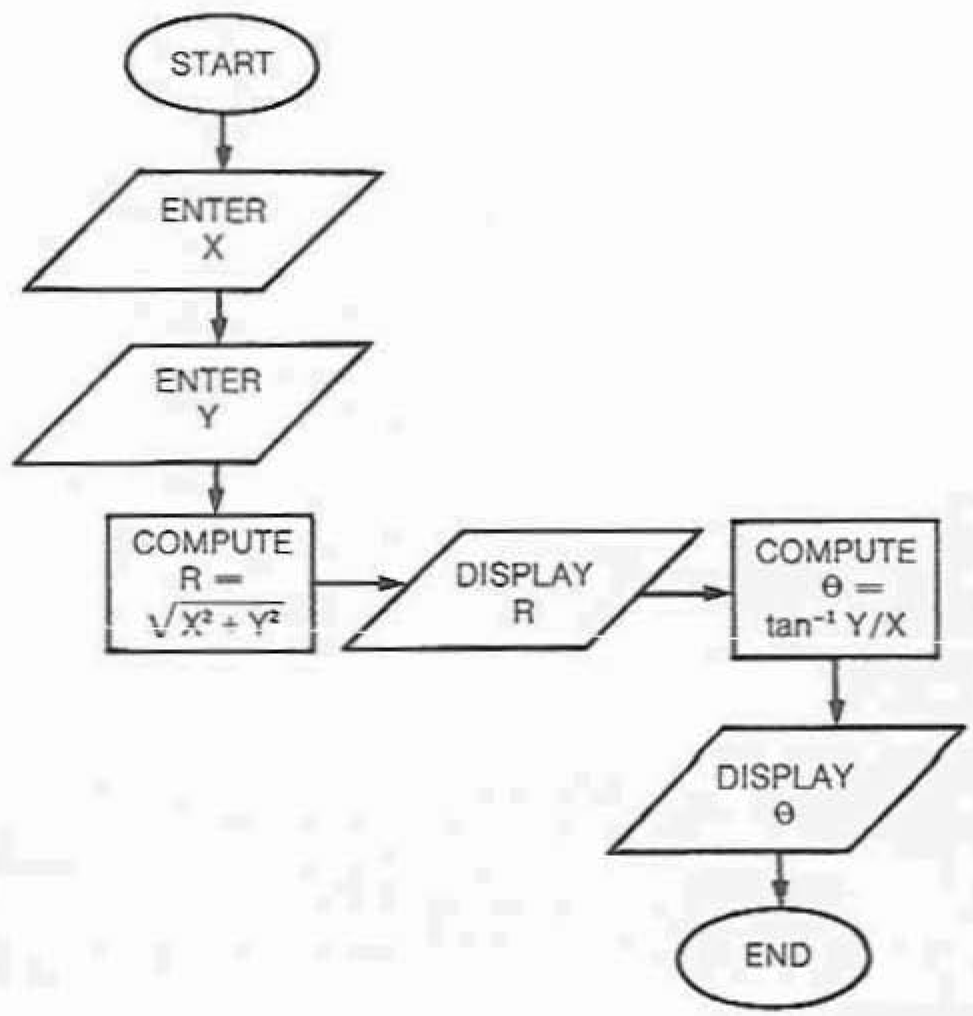
The programmable Scientist functions as a calculator while it is being programmed, thus enabling you to use actual data to get a meaningful result as you program. While it is not necessary to use actual data while keying in a sequence of programming steps, doing so for simple, non-iterative programs can be quite helpful. This feature lets you "debug" your program by seeing if the calculated result displayed at the end of programming is the same as your predicted result for the calculations involved. If it is, you have keyed in the program correctly.

Example: Program the Scientist to convert the rectangular coordinates X and Y to polar coordinates R and θ. Using actual variables X = 6 and Y = 8, we can can predict results of:

$$R = \sqrt{X^2 + Y^2} = \sqrt{6^2 + 8^2} = \sqrt{100} = 10, \text{ and}$$

$$\theta = \text{arc tan } Y/X = \text{arc tan } 8/6$$
$$= \text{arc tan } 1.3333333 = 53.12998$$

Desired flow of execution:



Loading the program.

Switch: LOAD position.									
STEP	KEY ENTRY	DATA ENTRY	REGISTER CONTENTS X	Y	Z	T	M	COMMENTS
1	start							Mark beginning of program.
2	halt							Pause for entry of a variable (X).
		6	6					X.
3	ENT		6.	6.				
4	ENT		6.	6.	6.			Store X in register Z.
5	×		36.	6.				X^2.
6	halt		36.	6.				Pause to enter Y.
		8	8	36.	6.		8.	Y.
7	MS		8	36.	6.		8.	Store Y in register M.
8	ENT		8.	8.	36.	6.	8.	
9	×		64.	36.	6.		8.	Y^2.
10	÷		100.	6.			8.	$X^2 + Y^2$.
11	√		10.	6.			8.	$\sqrt{X^2 + Y^2}$.
12	halt		10.	6.			8.	Pause to display R.
13	x-y		6.	10.			8.	Recover Y.
14	MR		8.	6.	10.		8.	Recall X.
15	x-y		6.	8.	10.		8.	Exchange to divide Y by X.
16	÷		1.3333333	10.			8.	Y/X.
17	arc		1.3333333	10.			8.	
18	tan		53.12998	10.			8.	θ displayed. End of program.

Running the program.
Now that the program for converting rectangular coordinates to polar coordinates has been loaded, convert the following rectangular coordinates to polar coordinates:

X = 5, Y = 9
X = 7, Y = 4
X = 3, Y = 3

Switch: RUN position.

KEY IN	DISPLAY SHOWS	COMMENTS
start		Starts first program and executes to first HALT.
5	5.	First X.
start	25.	Continue program to next HALT.
9	9	First Y.
start	10.29563	Continue program to next HALT. R displayed.
start	60.945697	Continue program to end. Θ displayed.
start	60.945697	Start first program.
7	7	Next X.
start	49.	Continue program.
4	4	Next Y.
start	8.062257	Next R displayed.
start	29.744463	Next Θ displayed.
start	29.744463	Start first program.
3	3	Next X.
start	9.	Continue program.
3	3	Next Y.
start	4.24264	Next R displayed.
start	45.000654	Next Θ displayed.

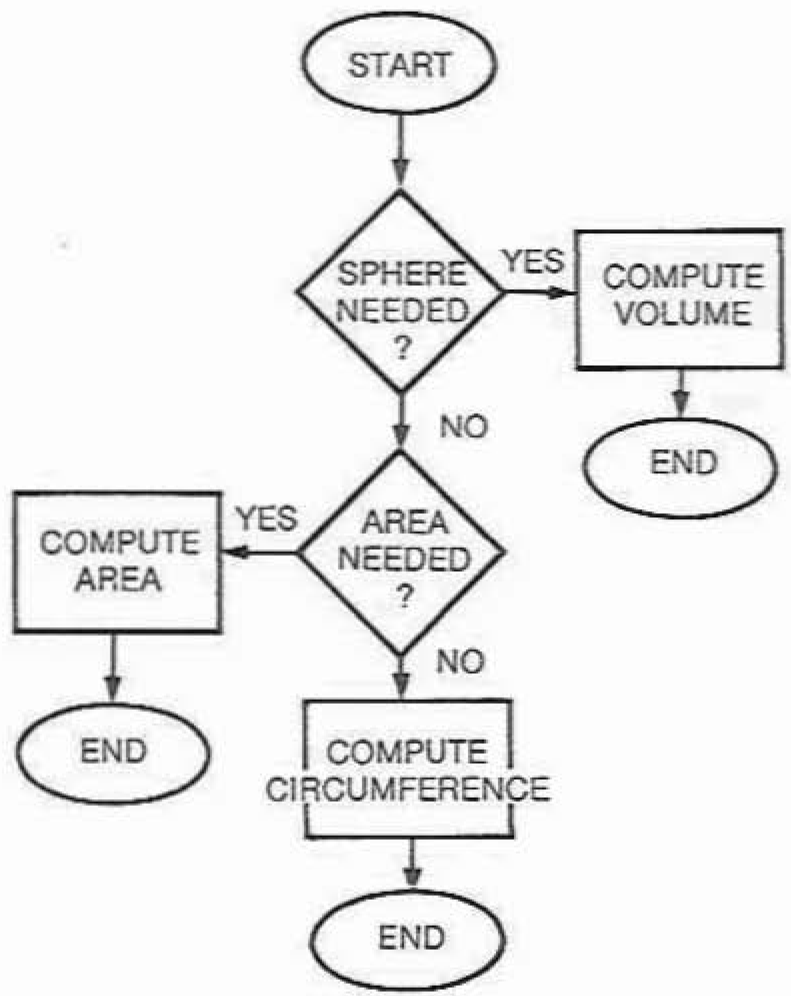
Entering Multiple Programs

Example: Find the area or circumference of a circle or volume of a sphere of radius r, whichever is needed. From Appendix B — Part 3:

Area of circle = πr^2,
Circumference of circle = $2\pi r$,
Volume of sphere = $4/3\pi r^3$.

It is apparent that no matter which formula is needed, r is going to be used. Thus the programs can be written to store the value of r in memory beforehand. No data is entered during the program.

Desired flow of execution:



Loading the program. Using r = 5 as a test variable.

STEP	KEY ENTRY	DATA ENTRY	REGISTER CONTENTS X	Y	Z	T	M	COMMENTS
		5	5					Test variable.
	MS		5.				5.	Store for use in the programs.
Switch: LOAD position.								
1	start		5.				5.	Mark beginning of first prorgam (area of circle).
2	π		3.1415927	5.			5.	π.
3	ENT		3.1415927	3.1415927	5.		5.	
4	MR		5.	3.1415927	5.		5.	Recall r.
5	ENT		5.	5.	3.1415927	5.	5.	
6	×		25.	3.1415927	5.		5.	r^2.
7	×		78.539817	5.			5.	πr^2. End of first program.
8	skip		78.539817	5.			5.	Mark beginning of second program (circumference of circle).
9	halt		78.539817	5.			5.	There are more than two programs. Each program subsequent to the first program must have a HALT.
10	MR		5.	78.539817	5.		5.	Since there is no data to enter at the HALT in Step 9, touch any key other than a data entry key (0-9, CHS, π).
11	ENT		5.	5.	78.539817	5.	5.	r.
12	π		3.1415927	5.	78.539817	5.	5.	π.
13	×		15.707963	78.539817	5.		5.	πr.
14	2		2	15.707963	78.539817	5.	5.	Since no HALT preceded this number entry, it is treated as a constant in the program.
15	×		31.415926	78.539817	5.		5.	2πr. End of second program.
16	skip		31.415926	78.539817	5.		5.	Mark beginning of third program (volume of sphere).
17	halt		31.415926	78.539817	5.		5.	Same as Step 9.
18	MR		5.	31.415926	78.539817	5.	5.	Recall r.
19	ENT		5.	5.	31.415926	78.539817	5.	
20	3		3	5.	31.415926	78.539817	5.	
21	y^x		124.99984	0	0	0	5.	r^3.
22	π		3.1415927	124.99984			5.	π.

STEP	KEY ENTRY	DATA ENTRY	REGISTER CONTENTS X	Y	Z	T	M	COMMENTS
23	×		392.69858				5.	πr^3.
24	4		4	392.69858			5.	Constant.
25	ENT		4.	4.	392.69858		5.	
26	3		3.	4.	392.69858		5.	
27	÷		1.3333333	392.69858			5.	4/3.
28	×		523.59809				5.	4/3 πr^3. End of third program.

Running the program.

Now that the programs for the area and circumference of a circle and the volume of a sphere of radius r have been loaded, solve the following problems:

Problem 1. Area and circumference of a circle of radius 7.

Problem 2. Circumference of a circle of radius 9 and volume of a sphere of radius 9.

Problem 3. Area of a circle of radius 6.5 and volume of a sphere of radius 6.5.

Problem 4. Area and circumference of a circle of radius 12.35 and volume of a sphere of radius 12.35.

Switch: RUN position.

KEY IN	DISPLAY SHOWS	COMMENTS
7	7	r = 7 for Problem 1.
MS	7.	Store radius in memory.
start	153.93804	Area of circle of r = 7.
skip	153.93804	Skip program 1 to start program 2.
start	43.982296	Circumference of circle of r = 7.
9	9	New radius.
MS	9.	Store in memory.
skip	9.	Skip program 1 to start program 2.
start	56.548668	Circumference of circle of r = 9.
skip	56.548668	Skip program 1.
skip	56.548668	Skip program 2 to start program 3.
start	3053.6295	Volume of sphere of r = 9.
6.5	6.5	New radius.
MS	6.5	Store in memory.
start	132.73229	Area of circle of r = 6.5.
skip	132.73229	Skip program 1.
skip	132.73229	Skip program 2.
start	1150.3467	Volume of sphere of r = 6.5.
12.35	12.35	New radius.
MS	12.35	Store in memory.
start	479.16357	Area of circle of r = 12.35.
skip	479.16357	Skip program 1.
start	77.597338	Circumference of circle of r = 12.35.
skip	77.597338	Skip program 1.
skip	77.597338	Skip program 2.
start	7890.2338	Volume of sphere of r = 12.35.

Entering Iterative Programs

At the end of a program, the programmer always positions program control at the beginning of the first program. This feature can be used to do iterative programs. The iterative part of the program is programmed in just once and then executed as many times as needed.

Example: Program the Scientist to find Chi Square (x^2) for the following data:

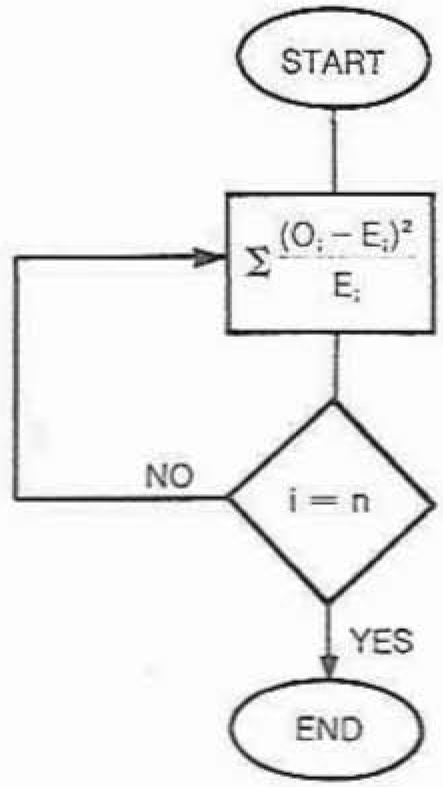
O_i	2	3	5	7	2
E_i	4	4	3	5	3

Using the equation:

$$\chi^2 = \sum_{i=1}^{n} \frac{(O_i - E_i)^2}{E_i}$$

We can program the equation and use the program n = 5 times.

Desired flow of execution:



Loading the program.

Since this is an iterative program, "real" variables cannot be used to get a test result at the end of programming. Use a "test" variable of 1 to avoid making logic errors (e.g. division by zero) during programming.

Switch: LOAD position.

STEP	KEY ENTRY	DATA ENTRY	REGISTER CONTENTS X	Y	Z	T	M	COMMENTS
		1	1					Enter test variable (1).
1	start		1					Mark beginning of program.
2	ENT		1.	1.				Since the first step in the program is ENT, the program will use whatever is in the display for data, thus eliminating the need for a HALT to enter one of the variables (O_i).
3	halt		1.	1.				Pause to enter E_i.
4	MS		1.	1.			1.	Store E_i for later division.
5	—		0.				1.	$O_i - E_i$.

STEP	KEY ENTRY	DATA ENTRY	X	Y	Z	T	M	COMMENTS
6	ENT		0.	0.		1.		
7	×		0.			1.		$(O_i - E_i)^2$.
8	MR		1.	0.		1.		Recall E_i.
9	÷		0.			1.		$\frac{(O_i - E_i)^2}{E_i}$
10	+		0.			1.		$\Sigma \frac{(O_i - E_i)^2}{E_i}$ End of program.

(X, Y, Z, T, M: REGISTER CONTENTS)

Running the program.

Figuring x^2 for the following data:

O_i	2	3	5	7	2
E_i	4	4	3	5	3

Switch: RUN position.

KEY IN	DISPLAY SHOWS	COMMENTS
0	0	
ENT	0.	
ENT	0.	Clear registers X and Y.
2	2	O_1.
start	2.	
4	4	E_1.
start	1.	$\Sigma(O_i - E_i)^2/E_i$. This is the basic program. Continue to re-run it as long as necessary (n = 5 times).
3	3	O_2.
start	3.	
4	4	E_2.
start	1.25	Summation with n = 2.
5	5	O_3.
start	5.	
3	3	E_3.
start	2.5833333	Summation with n = 3.
7	7	O_4.
start	7.	
5	5	E_4.
start	3.3833333	Summation with n = 4.
2	2	O_5.
start	2.	
3	3	E_5.
start	3.7166666	Summation with n = 5. End of program. Chi square calculated.

Looping and Branching

Using the start key to loop, and the skip key to branch, allows an iterative calculation and use of the results of that calculation in subsequent calculations. The following is an example of this technique.

Example: Program the Scientist to find the mean, variance and standard deviation of the following data: (2, 7, 3, 5, 2).

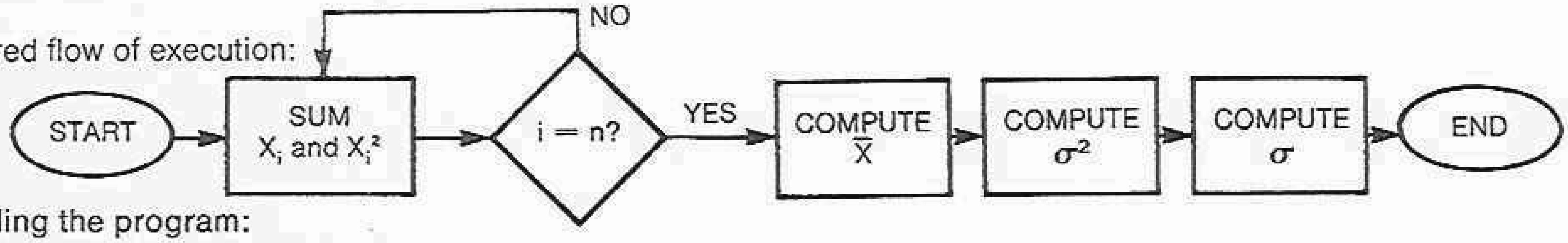
Using the formulas:

Mean = $\bar{x} = \Sigma x/n$,

Variance = $\sigma^2 = \frac{\Sigma x^2 - n(\Sigma x/n)^2}{n-1}$,

Standard Deviation = $\sigma = \sqrt{\sigma^2}$.

Desired flow of execution:



Loading the program:

Since this is an iterative program, we will load the stack with a dummy variable = 2 to avoid making logic errors (e.g. dividing by zero).

Switch: LOAD position.								
LINE NO.	KEY ENTRY	DATA ENTRY	REGISTER CONTENTS X	Y	Z	T	M	COMMENTS
	2 ENT ENT							Dummy variable x_i.
	start							
1	MS		x_i	Σx_i	n	$\Sigma(x_i)^2$	x_i	x_i
2	+		Σx_i	n	$\Sigma(x_i)^2$		x_i	Σx_i
3	MR		x_i	Σx_i	n	$\Sigma(x_i)^2$	x_i	
4	x–y		Σx_i	x_i	n	$\Sigma(x_i)^2$	x_i	
5	MS		Σx_i	x_i	n	$\Sigma(x_i)^2$	Σx_i	Store Σx_i.
6	C		x_i	n	$\Sigma(x_i)^2$		Σx_i	
7	roll		n	$\Sigma(x_i)^2$		x_i	Σx_i	
8	x–y		$\Sigma(x_i)^2$	n			Σx_i	
9	roll		n		x_i	x_i	Σx_i	
10	roll			x_i	$\Sigma(x_i)^2$	$\Sigma(x_i)^2$	Σx_i	
11	roll		x_i	$\Sigma(x_i)^2$	n	n	Σx_i	
12	ENT		x_i	x_i	$\Sigma(x_i)^2$		Σx_i	
13	×		x_i^2	$\Sigma(x_i)^2$	n	n	Σx_i	x_i^2.
14	+		$\Sigma(x_i)^2$	n			Σx_i	$\Sigma(x_i)^2$.
15	x–y		n	$\Sigma(x_i)^2$				
16	1		1	n	$\Sigma(x_i)^2$		Σx_i	
17	+		n	$\Sigma(x_i)^2$			Σx_i	Increment n count.
18	MR		Σx_i	n	$\Sigma(x_i)^2$		Σx_i	Set up to reiterate for next x_i. End of iterative routine to sum up x_i, $(x_i)^2$ and n. Keying in a new x_i at this point and touching start will perform another iteration of the routine.

LINE NO.	KEY ENTRY	DATA ENTRY	REGISTER CONTENTS					COMMENTS
			X	Y	Z	T	M	
19	skip		Σx_i	n	$\Sigma(x_i)^2$			Mark beginning of second program to find x, σ^2 and σ.
	x–y		n	Σx_i	$\Sigma(x_i)^2$		Σx_i	
21	MS		n	Σx_i	$\Sigma(x_i)^2$		n	
22	÷		$\Sigma x_i/n$	$\Sigma(x_i)^2$			n	x = mean.
23	halt		$\Sigma x_i/n$	$\Sigma(x_i)^2$			n	Pause to display x.
24	ENT		$\Sigma x_i/n$	$\Sigma x_i/n$	$\Sigma(x_i)^2$		n	
25	×		$(\Sigma x_i/n)^2$	$\Sigma(x_i)^2$			n	
26	MR		n	$(\Sigma x_i/n)^2$	$\Sigma(x_i)^2$		n	
27	×		$n(\Sigma x_i/n)^2$	$\Sigma(x_i)^2$			n	
28	—		$\Sigma(x_i)^2-n(\Sigma x_i/n)^2$				n	
29	MR		n	$\Sigma(x_i)^2-n(\Sigma x_i/n)^2$			n	
30	1		1	n	$\Sigma(x_i)^2-n(\Sigma x_i/n)^2$		n	
31	—		n−1	$\Sigma(x_i)^2-n(\Sigma x_i/n)^2$				
32	÷		$\frac{\Sigma(x_i)^2-n(\Sigma x_i/n)^2}{n-1}$				n	Variance.
33	halt		$\frac{\Sigma(x_i)^2-n(\Sigma x_i/n)^2}{n-1}$				n	Pause to display σ^2.
34	√		$\sqrt{\frac{\Sigma(x_i)^2-n(\Sigma x_i/n)^2}{n-1}}$				n	Display σ (Standard Deviation).

Running the program.

Calculate the mean, variance and standard deviation for the following data: (2, 7, 3, 5, 2).

Switch: RUN position.

KEY IN	DISPLAY SHOWS	COMMENTS
C	0	Clears stack.
C	0	Clears stack.
C	0	Clears stack.
C	0	Clears stack.
2	2	x_1.
start	2.	Start program 1, loop to sum x, x^2 and n.
7	7	x_2.
start	9.	
3	3	x_3.
start	12.	
5	5	x_4.
start	17.	
2	2	x_5.
start	19.	The iteration (looping) part of the program is finished. Branch to the part of the program that uses the data obtained in the interative part.
skip	3.8	Program pauses to display x.
start	4.7	Program pauses to display σ^2.
start	2.1679483	End of program. Program displays σ.

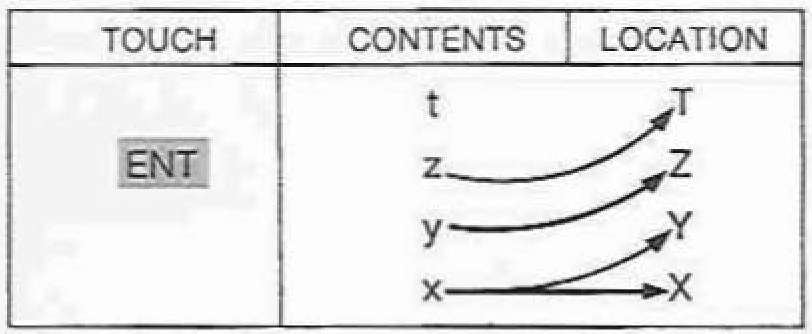
1. To clear display before starting program, touch C until a zero appears in the display. To clear memory, touch 0 MS.
2. To load a program, move LOAD/STEP/RUN switch to LOAD position.
3. Mark the beginning of the first program with start. Mark the beginning of all subsequent programs with skip. If more than two programs are being stored, all except the first must have a HALT command as part of the program to permit accessing of those programs.
4. To interrupt a program, whether to enter a variable or to display a result, touch halt.
5. To enter a constant, key in the desired number. It becomes part of the program.
6. To enter a variable, key in halt, then the desired number. It does not become part of the program, but is used to "debug" the program.
7. To run programs, move the LOAD/STEP/RUN switch to RUN position.
8. To start the first program, touch start. To start second program, touch skip. To start n^{th} program, touch skip n-1 times.

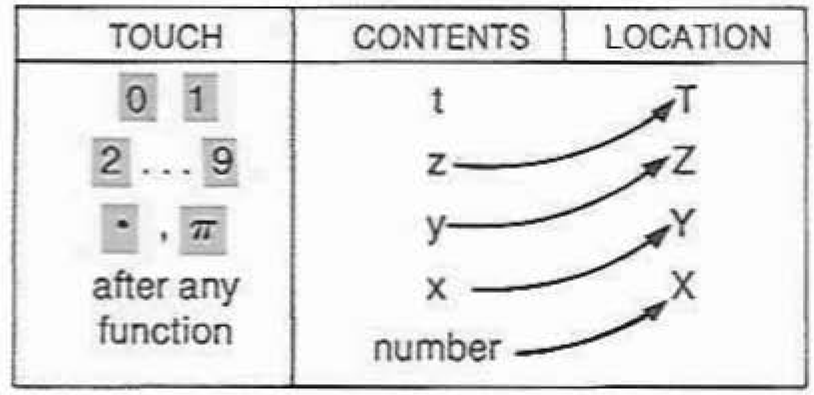
Error Conditions

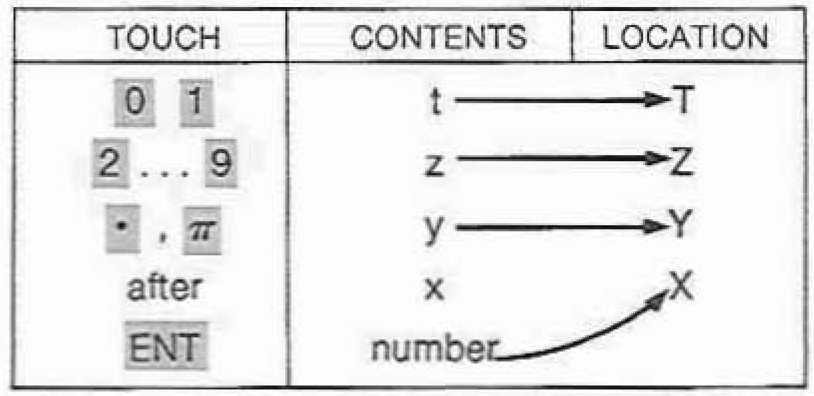
In the event of a logic error (e.g., division by zero) the Novus Scientist will display all zeros and decimal points. An error condition is reset by touching C. All registers are cleared to zero. Memory is not affected by error conditions. See Appendix C, Table 1, for a complete table of improper operations.

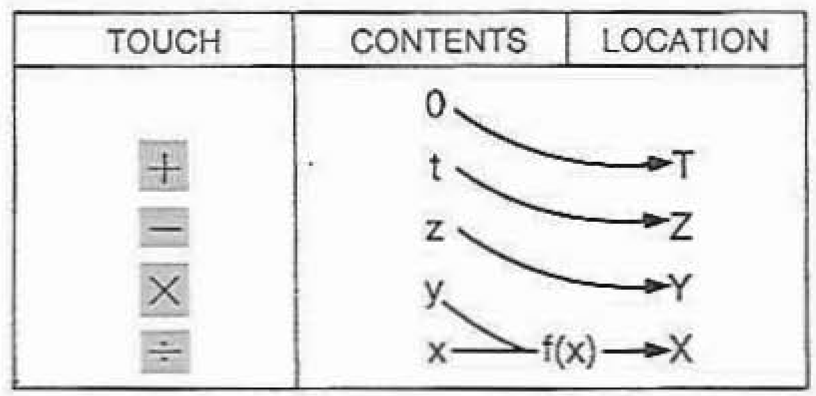
Appendix A — Stack Diagrams

The following diagrams show what happens to the stack for each operation on the Novus Scientist. Contents of registers are indicated by lower case letters x, y, z and t. Locations are indicated by capital letters X, Y, Z and T. The display always shows the contents of register X. Memory is register M.









f(x): y + x → X
y − x → X
y × x → X
y ÷ x → X

TOUCH	CONTENTS	LOCATION
C↓	0	→ T
	t	→ Z
	z	→ Y
	y	→ X
	x	→ lost

TOUCH	CONTENTS	LOCATION
X →Y	t	→ T
	z	→ Z
	y	→ X
	x	→ Y

TOUCH	CONTENTS	LOCATION
EE after number entry	t	→ T
	z	→ Z
	y	→ Y
	x	→ X*

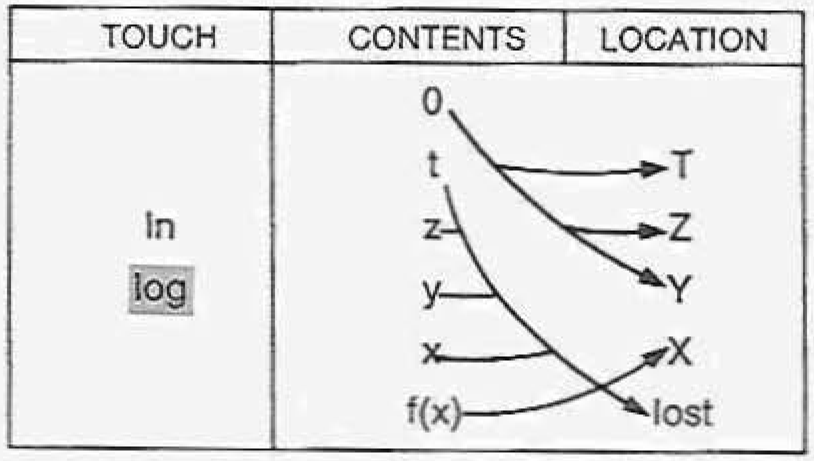
*Note: Calculator conditioned to accept exponent.

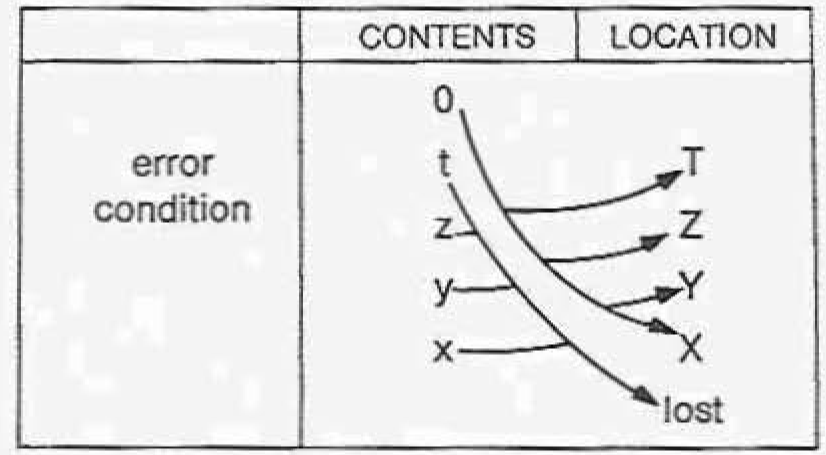
TOUCH	CONTENTS	LOCATION
CHS	t	→ T
	z	→ Z
	y	→ Y
	x—CHS x	→ X

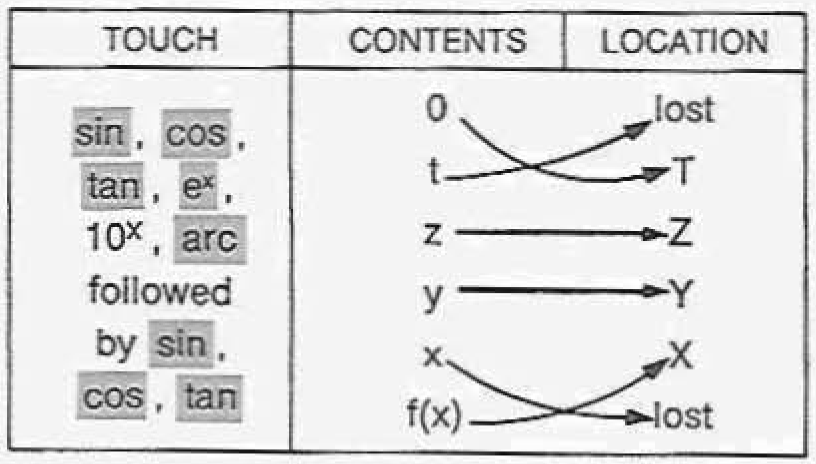
TOUCH	CONTENTS	LOCATION
ROLL	t	→ Z
	z	→ Y
	y	→ X
	x	→ T

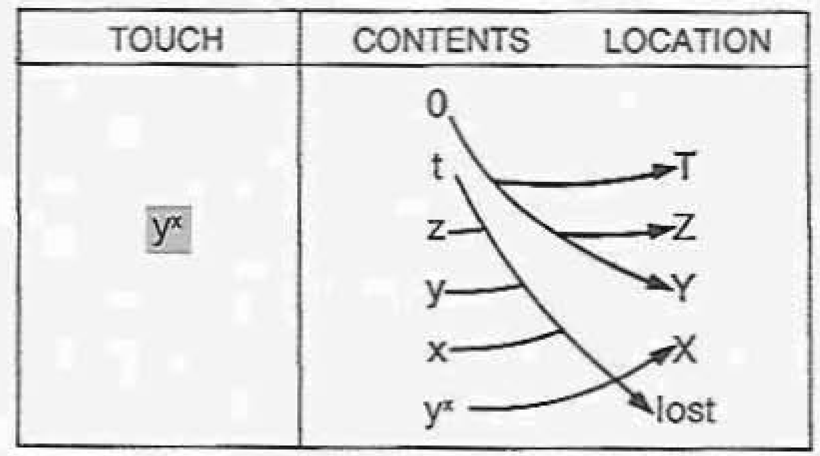
TOUCH	CONTENTS	LOCATION
MS	t	→ T
	z	→ Z
	y	→ Y
	x	→ X, → M
	m	→ lost

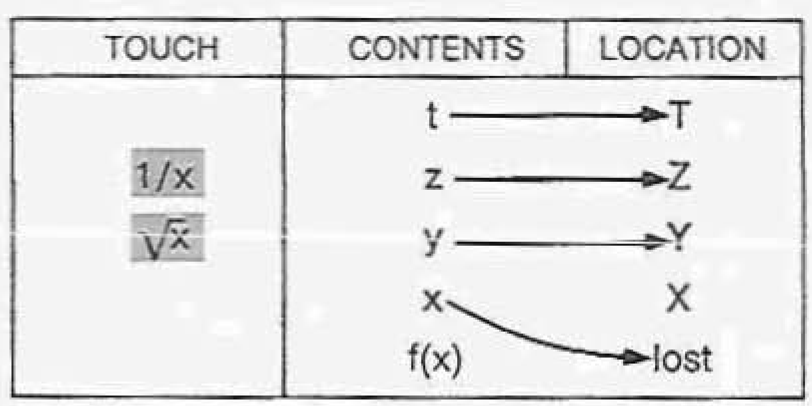
TOUCH	CONTENTS	LOCATION
MR	t	→ lost
	z	→ T
	y	→ Z
	x	→ Y
	m	→ X, → M


TOUCH
CONTENTS
LOCATION
ln
log
0
t
z
y
x
f(x)
T
Z
Y
X
lost


CONTENTS
LOCATION
error condition
0
t
z
y
x
T
Z
Y
X
lost


TOUCH
CONTENTS
LOCATION
sin, cos, tan, eˣ, 10ˣ, arc followed by sin, cos, tan
0
t
z
y
x
f(x)
lost
T
Z
Y
X
lost


TOUCH
CONTENTS
LOCATION
yˣ
0
t
z
y
x
yˣ
T
Z
Y
X
lost


TOUCH
CONTENTS
LOCATION
1/x
√x
t
z
y
x
f(x)
T
Z
Y
X
lost

Some Examples

In the previous sections of this manual is a summary of how the functions of the Novus Scientist work. This appendix demonstrates the versatility of the Scientist in a variety of disciplines.

MATHEMATICS

Real roots of a quadratic equation.

Given the equation $2x^2 + 3x - 4$, find the roots: x_1 and x_2.

Roots x_1 and x_2 can be found from the equation:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$= \frac{-b}{2a} \pm \frac{\sqrt{b^2 - 4ac}}{2a}$$

where: a= 2, b = 3 and c = -4.

STEP	KEY IN	DISPLAY SHOWS	COMMENTS
1	2	2	a.
2	ENT	2.	
3	+	4.	2a.
4	MS	4.	Save for use in dividing.
5	3	3	b.
6	CHS	-3.	-b.
7	x-y	4.	
8	÷	-0.75	-b/2a.
9	ENT	-0.75	
10	ENT	-0.75	Save in register Z for further use in addition and subtraction of the radical.
11	×	0.5625	$b^2/4a^2$.
12	4	4	
	CHS	-4.	c.
13	ENT	-4.	
14	+	-8.	2c.
15	MR	4.	2a.
16	÷	-2	c/a.
17	−	2.5625	$b^2/4a^2 - c/a = b^2 - 4ac/2a$.
18	√	1.600781	$\sqrt{b^2 - 4ac}/2a$.
19	MS	1.600781	
20	+	0.850781	First real root. $x_1 = -b/2a + \sqrt{b^2 - 4ac}/2a$.
21	MR	1.600781	$\sqrt{b^2 - 4ac}/2a$.
22	−	-0.75	$-b/2a + \sqrt{b^2 - 4ac}/2a - \sqrt{b^2 - 4ac}/2a = -b/2a$.
23	MR	1.600781	$\sqrt{b^2 - 4ac}/2a$.
24	−	-2.350781	Second real root. $x_2 = -b/2a - \sqrt{b^2 - 4ac}/2a$.

Degrees, minutes and seconds to decimal degrees conversion. Convert the following degrees, minutes and seconds to decimal degrees:

56°23′44.5″

KEY IN	DISPLAY SHOWS	COMMENTS
44.5	44.5	Seconds.
ENT	44.5	
60	60	60 seconds/minute.
MS	60.	
÷	0.7416666	
23	23	Minutes.
+	23.741666	
MR	60.	60 minutes/degree.
÷	0.3956944	
56	56	Degrees.
+	56.395694	Decimal degrees.

Polar to rectangular coordinate conversion. Convert coordinates $\Theta = 35°$, $R = 7$ to rectangular coordinates.

Using the formula:

$X = R \cos \Theta$ and

$Y = R \sin \Theta$

KEY IN	DISPLAY SHOWS	COMMENTS
35	35	θ.
ENT	35.	
7	7	R.
MS	7	Store R in register M.
x–y	35.	
ENT	35.	Store θ in register Y.
cos	0.8191518	cos θ.
MR	7.	Recall R.
×	5.7340626	X displayed = R cos θ.
x–y	35.	θ.
sin	0.5735766	sin θ.
MR	7.	Recall R.
×	4.0150362	Y displayed = R sin θ.

Note: To see X again, touch x–y.

See Appendix B — Part 4 for a stack diagram of this example.

Rectangular to polar coordinate conversion. Convert coordinates X=6, Y=8 to polar coordinates R and Θ.

Using the formula:

$$R = \sqrt{X^2 + Y^2}$$

$$\Theta = \arc\tan \frac{Y}{X}$$

KEY IN	DISPLAY SHOWS	COMMENTS
6	6	X coordinate.
ENT	6.	
ENT	6.	Store X in register Z.
×	36.	X^2.
8	8	Y coordinate.
MS	8	Store Y in register M.
ENT	8.	
×	64.	Y^2.
+	100.	$X^2 + Y^2$.
√	10.	$R = \sqrt{X^2 + Y^2}$.
x-y	6.	Recover X.
MR	8.	Recall Y.
x-y	6.	Exchange to divide Y by X.
÷	1.3333333	Y/X.
arc	1.3333333	
tan	53.12998	Θ = arc tan Y/X.

Note: To see R again, touch x-y.

See Appendix B — Part 4 for a stack diagram of this example.

What gravitational force does the earth exert on the moon? From Newton's law of universal gravitation,

$$F = G\frac{m_1 m_2}{r^2}$$

where: m_1 = mass of the earth = 5.98×10^{24} kg,

m_2 = mass of the moon = 7.36×10^{22} kg,

r = distance from the earth to the moon = 3.84×10^8 m

G = Universal gravitational constant = 6.67×10^{-11} N–m²/ kg²

therefore:

$$F = 6.67 \times 10^{-11} \times \frac{5.98 \times 10^{24} \times 7.36 \times 10^{22}}{(3.84 \times 10^8)^2}$$

$$= 1.99 \times 10^{20} \text{ newtons.}$$

KEY IN	DISPLAY SHOWS		COMMENTS
6.67	6.67		
EE	6.67		
11	6.67	11	
CHS	6.67	−11	Universal gravitational constant.
ENT	6.67	−11	
5.98	5.98		
EE	5.98		
24	5.98	24	Mass of the earth.
ENT	5.98	24	
7.36	7.36		
EE	7.36		
22	7.36	22	Mass of the moon.
×	4.40128	47	$m_1 m_2$.

3.84	3.84		
EE	3.84		
8	3.84	08	Distance from earth to moon.
ENT	3.84	08	
×	1.47456	17	r^2.
÷	2.984809	30	$m_1 m_2/r^2$.
×	1.9908676	20	F = gravitational force.

How many electrons pass a certain point per second in a wire that carries a current of 12 amps?

Since 1 amp is defined as 1 coulomb/second, 12 A = 12 C/s. The electron charge = e = 1.6 × 10^{-19}C, so a current of 12A corresponds to a flow of:

$$\frac{12\ \text{C/s}}{1.6 \times 10^{-19}\ \text{C/electron}} = 7.5 \times 10^{19}\ \text{electrons/sec.}$$

KEY IN	DISPLAY SHOWS		COMMENTS
12	12		Amperes.
ENT	12.		
1.6	1.6		
EE	1.6		
19	1.6	19	
CHS	1.6	−19	Electron charge.
÷	7.5	19	Electrons/second.

What is the velocity of a proton (mass = 1.67 × 10^{-27} kg) which is accelerated through a potential difference of 300 volts?

Since the charge on a proton is +e, its kinetic energy is 300eV (electron-volts) x 1.6 x 10^{-19} joules/eV = 4.8 x 10^{-17} joules.

Using the equation KE = ½mv², where KE = kinetic energy of the electron, m = mass of the proton = 1.67 x 10^{-27} and v = velocity of the electron.

$$v = \sqrt{\frac{2KE}{m}} = \sqrt{\frac{2 \times 4.8 \times 10^{-17}}{1.67 \times 10^{-27}}}$$
$$= 2.397 \times 10^5\ \text{meters/sec.}$$

KEY IN	DISPLAY SHOWS		COMMENTS
300	300		Potential difference in eV.
ENT	300.		
1.6	1.6		
EE	1.6		
19	1.6	19	
CHS	1.6	−19	Mass of proton.
×	4.8	−17	Kinetic energy of proton.
2	2		
×	9.6	−17	
1.67	1.67		
EE	1.67		
27	1.67	27	
CHS	1.67	−27	Mass of the proton.
÷	5.7485029	10	
√	239760.35		Velocity of the proton.

What is the attractive force between a proton (charge +e) and an electron (charge −e) in a hydrogen atom where the radius of the electron orbit is 5.3 x 10^{-11} m?

Using Coulomb's law:

$$F = k\frac{Q_1Q_2}{r^2}$$

where: k = Universal constant = 9.0×10^9 N–m²/C²

Q_1 = charge on particle 1 = charge of proton = 1.6×10^{-19}C,

Q_2 = charge on particle 2 = charge of electron = 1.6×10^{-19}C,

r = distance between two charges = 5.3×10^{-11}m.

$$F = 9.0 \times 10^9 \times \frac{(1.6 \times 10^{-19})^2}{(5.3 \times 10^{-11})^2}$$

$$= 8.2 \times 10^{-8} \text{ newtons.}$$

KEY IN	DISPLAY SHOWS		COMMENTS
9.	9.		
EE	9.		
9	9.	09	Universal constant.
ENT	9.	09	
1.6	1.6		
EE	1.6		
19	1.6	19	
CHS	1.6	–19	$Q_1 = Q_2$.
ENT	1.6·	–19	
×	2.56	–38	Q_1Q_2.
5.3	5.3		
EE	5.3		
11	5.3	11	
CHS	5.3	–11	r.
ENT	5.3	–11	
×	2.809	–21	r^2.
÷	9.113563	–18	Q_1Q_2/r^2.
×	8.2022067	–08	Attractive force F.

One of the predictions of Einstein's theory of relativity is that the mass of moving body is greater than its mass at rest. Using the equation:

$$M = \frac{M_O}{\sqrt{1 - v^2/c^2}}$$

Where: M = mass of the moving body,

M_O = mass of the body at rest,

v = velocity of the body,

c = speed of light (2.997×10^8 m/sec).

Find the mass of an electron traveling at 75% of the speed of light. If the rest mass of an electron is 9.109×10^{-31} kg. If $v = .75c$, then the equation becomes:

$$M = \frac{M_O}{\sqrt{1 - (.75c)^2/c^2}} = \frac{M_O}{\sqrt{1 - (.75)^2}}$$

Substituting:

$$M = \frac{9.109 \times 10^{-31}}{\sqrt{1 - (.75)^2}}$$

KEY IN	DISPLAY SHOWS		COMMENTS
9.109	9.109		
EE	9.109	00	
31	9.109	31	
CHS	9.109	–31	Mass of electron at rest.
ENT	9.109	–31	
1	1		
ENT	1.		
.75	0.75		
ENT	0.75		
×	0.5625		$(.75)^2$
–	0.4375		$1 - (.75)^2$
√	0.6614378		$\sqrt{1-(.75)^2}$
÷	1.3771514	–30	Mass of electron travelling at 75% the speed of light, $= M_o/\sqrt{1-(.75)^2}$

Determine the rise of the mercury column in a glass tube of inside diameter 0.6 mm which stands vertically with one end immersed in mercury. The angle of contact with the mercury is 57.3° and the surface tension is 490 dynes/cm.

Using the formula: $h = 2T/rdg (\cos \theta)$

where: h = height of mercury in tube,
T = surface tension,
r = inside radius of tube (½ diameter),
d = density of the liquid = 13.6 g/cm^3 for mercury,
g = acceleration due to gravity = 980 cm/sec^2.

$$h = \frac{2 \times 490 \text{ dynes/cm}}{0.03 \text{ cm} \times 13.6 \text{ g/cm}^3 \times 980 \text{ cm/sec}^2} \times \cos 57.3°$$

$$= 1.324 \text{ cm.}$$

KEY IN	DISPLAY SHOWS		COMMENTS
2	2		
ENT	2.		
490	490		Surface tension.
×	980.		
.03	0.03		Inside radius in cm.
ENT	3.	-02	
13.6	13.6		Density of mercury.
×	0.408		
980	980.		Gravity.
×	399.84		
÷	2.4509803		
57.3	57.3		Angle of contact.
cos	0.5402406		
×	1.324119		Rise of column in cm.

How many gram-atoms of Iron (Fe) are present in 250 grams of iron?

Since the atomic mass of Fe = 55.847 atomic mass units (u) = 55.847 grams/gram atom,

$$\text{Gram-atoms of Fe} = \frac{\text{mass of Fe}}{\text{atomic mass of Fe}} = \frac{250 \text{ grams}}{55.847 \text{ g/gram-atom}}$$

KEY IN	DISPLAY SHOWS	COMMENTS
250	250	Grams of Fe.
ENT	250.	
55.847	55.847	Atomic mass of Fe.
÷	4.476516	Gram-atoms of Fe in 250 grams.

In the above example, how many atoms of Fe are in the sample?

Since the number of atoms in a sample of any substance is the number of gram-atoms it contains multiplied by Avogadro's number ($N = 6.023 \times 10^{23}$ atoms/gram-atom),

Atoms of Fe = 4.476516 gram-atoms × 6.023×10^{23} atoms/gram-atom = 4.476516 × 6.023×10^{23} = 2.6962×10^{24} atoms.

KEY IN	DISPLAY SHOWS		COMMENTS
4.476516	4.476516		Gram-atoms of Fe.
ENT	4.476516		
6.023	6.023		
EE	6.023		
23	6.023	23	Avogadro's number.
×	2.6962055	24	Atoms of Fe.

What is the molarity of a solution that contains 135 grams of calcium chloride, $CaCl_2$, per liter?

Using the formula mass of $CaCl_2$:

$1\ Ca = 1 \times 40.08\ u = 40.08\ u$
$2\ Cl = 2 \times 35.453\ u = 70.906\ u$

$110.986\ u = 110.986\ g/mole$

in the equation:

$$\text{number of moles} = \frac{\text{mass of } CaCl_2}{\text{formula mass of } CaCl_2}$$

$$= \frac{135 \text{ grams}}{110.986 \text{ g/mole}} = 1.21 \text{ mole.}$$

So the concentration of the solution is 1.21 moles/liter.

KEY IN	DISPLAY SHOWS	COMMENTS
40.08	40.08	Atomic mass of Ca.
ENT	40.08	
35.453	35.453	Atomic mass of Cl.
ENT	35.453	
2	2	
×	70.906	Atomic mass of Cl_2.
+	110.986	Formula mass of $CaCl_2$.
135	135	Grams of $CaCl_2$.
x-y	110.986	
÷	1.2163696	Moles per liter.

What is the tension at the ends of a cable where the span is 700 feet and the sag is 45 feet if each cable of the suspension bridge carries a horizontal load of 620 lbs/ft?

Using the equation:

$$T = \tfrac{1}{2} wa \sqrt{1 + a^2/16d^2}$$

where: T = tension,
w = weight (horizontal load),
a = length of span,
d = sag,

$$= \tfrac{1}{2} \times 620 \times 700 \times \sqrt{1 + 700^2/16 \times 45^2}$$

$$= 871342 \text{ lbs.}$$

KEY IN	DISPLAY SHOWS	COMMENTS
700	700	Length of span (a).
MS	700.	
ENT	700.	
×	490000.	a^2.
16	16.	
ENT	16.	
45	45	Sag (d).
ENT	45.	
×	2025.	d^2.
×	32400.	$16d_2$.
÷	15.123456	$a^2/16d^2$.
1	1	
+	16.123456	$1 + a^2/16d^2$.
√	4.015401	$\sqrt{1 + a^2/16d^2}$.
MR	700.	a.
×	2810.7807	$a \times \sqrt{1 + a^2/16d^2}$.
620	620	Weight (w).
×	1742684.	$w \times a \times \sqrt{1 + a^2/16d^2}$.

1	1	
ENT	1.	
2	2	
÷	0.5	
×	871342.	$\frac{1}{2} \times w \times a \times \sqrt{1 + a^2/16d^2}$.

After how long a time will the charge oscillations in a LCR circuit decay to half-amplitude if L = 10 mh, C = 1.0 μf and R = 0.1 ohm?

The oscillation amplitude will have decreased to half when the amplitude factor $e^{-Rt/2L}$ in the equation $q = q_m e^{-Rt/2L} \cos \omega' t$ has the value one-half, or

$$\frac{1}{2} = e^{-R/t2L}$$

This leads to the equation:

$$t = \frac{2L}{R} \ln 2$$

$$= \frac{(2)(10 \times 10^{-3})(\ln 2)}{0.10}$$

KEY IN	DISPLAY SHOWS	COMMENTS
2	2	
ENT	2.	
10	10	
EE	10	
3	10 03	
CHS	10 -03	Inductance (L).
×	2. -02	2L.
2	2	
ln	0.6931475	
×	1.386295 -02	2L ln 2.
.10	0.10	Resistance (R).
÷	0.1386295	Seconds to decrease to half amplitude. = t = 2L/R ln 2.

What is the equivalent resistance of a 220 ohm resistor, a 145 ohm resistor and a 175 ohm resistor connected in parallel?

Using the equation:

$$R_{eq} = \frac{1}{1/R_1 + 1/R_2 + 1/R_3}$$

$$= \frac{1}{1/220 + 1/145 + 1/175}$$

KEY IN	DISPLAY SHOWS	COMMENTS
220	220	R_1.
1/x	4.545454 -03	$1/R_1$.
ENT	4.545454 -03	
145	145	R_2.
1/x	6.896551 -03	$1/R_2$.
+	1.1442005 -02	
175	175	R_3.
1/x	5.714285 -03	$1/R_3$.
+	1.715629 -02	
1/x	58.28766	$R_{eq} = \frac{1}{1/R_1 + 1/R_2 + 1/R_3}$

Find the capacitance of a capacitor having eleven 1-sq-inch plates with a dielectric of mica 5 mils thick.

Using the formula:

$$C = \frac{0.0885\, kA\, (n - 1)}{d}$$

where: k = dielectric constant = 6.5 for mica,
A = area of one plate in square centimeters,
n = the number of plates,
d = distance between plates in centimeters.

$$= \frac{0.0885 \times 1 \times (2.54\ \text{cm/in})^2 \times (11 - 1)}{5 \times 10^{-3}\ \text{in} \times 2.54\ \text{cm/in}}$$

= 449.58 picofarads.

KEY IN	DISPLAY SHOWS	COMMENTS
0.0885	0.0885	
ENT	8.85 -02	
2.54	2.54	cm/in.
ENT	2.54	
×	6.4516	$(cm/in)^2$.
×	0.5709666	
11	11	n.
ENT	11.	
1	1	
−	10.	
×	5.709666	0.0885kA (n−1).
5	5	
EE	5.	
3	5. 03	
CHS	5. -03	d.
ENT	5. -03	
2.54	2.54	
×	1.27 -02	
÷	449.58	

STATISTICS

Compute the mean ($\bar{x}$) of the following data: (2, 7, 3, 5, 2).

Using the formula:

$$\bar{x} = \frac{\Sigma x}{n}$$

KEY IN	DISPLAY SHOWS	COMMENTS
2	2	x_1.
ENT	2.	
7	7	x_2.
+	9.	
3	3	x_3.
+	12.	
5	5	x_4.
+	17.	
2	2	x_5.
+	19.	
5	5	n.
÷	3.8	Mean ($\bar{x}$).

(Steps from 7 through the last + : Repeat these steps n−1 times.)

Compute the harmonic mean (M_h) of the following data: (2, 7, 3, 5, 2).

Using the formula:

$$M_h = \frac{n}{\Sigma \frac{1}{x}}$$

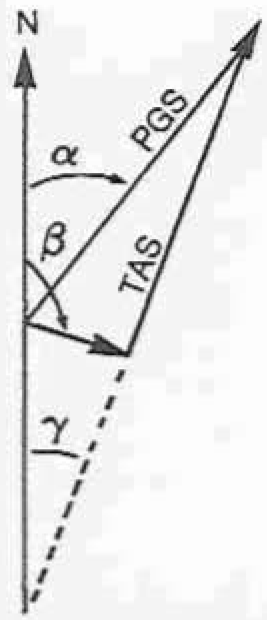
KEY IN	DISPLAY SHOWS	COMMENTS
2	2	x_1.
1/x	0.5	
7	7	x_2. (Repeat these steps n–1 times.)
1/x	0.1428571	
+	0.6428571	
3	3	x_3.
1/x	0.3333333	
+	0.9761904	
5	5	x_4.
1/x	0.2	
+	1.1761904	
2	2	x_5.
1/x	0.5	
+	1.6761904	
5	5	n.
x–y	1.6761904	
÷	2.9829546	Harmonic mean (M_h).

Compute the geometric mean (M_g) of the following data: (2, 7, 3, 5, 2).

Using the formula:

$$M_g = \sqrt[n]{(x_1)(x_2)(x_3)\dots(x_n)}$$

KEY IN	DISPLAY SHOWS	COMMENTS
2	2	x_1.
ENT	2.	
7	7	x_2. (Repeat these steps n–1 times.)
×	14.	
3	3	x_3.
×	42.	
5	5	x_4.
×	210.	
2	2	x_5.
×	420.	
5	5	n.
1/x	0.2	n^{th} root.
y^x	3.3469546	Geometric mean (M_g).



Find the predicted ground speed and true heading for a planned flight with the following flight triangle factors known:

$\sphericalangle\alpha$ = true course = 30° from North.
$\sphericalangle\beta$ = wind direction = 50° from North.
TAS = true air speed = 140 mph.
V = wind velocity = 42 mph.
$\sphericalangle\gamma$ = true heading = ?
PGS = predicted ground speed = ?

Predicted Ground Speed

Using the equation:

$$PGS = V\cos(\beta-\alpha) + \sqrt{[V\cos(\beta-\alpha)]^2 - V^2 + TAS^2}$$
$$= 42\cos(50-30) + \sqrt{[42\cos(50-30)]^2 - 42^2 + 140^2}.$$

KEY IN	DISPLAY SHOWS	COMMENTS
42	42	Wind velocity (V).
ENT	42.	
50	50	Wind direction ($\sphericalangle\beta$).
ENT	50.	
30	30	True course ($\sphericalangle\alpha$).
−	20.	
cos	0.9396926	
×	39.467089	$V\cos(\beta-\alpha)$.
MS	39.467089	Store for further use.
ENT	39.467089	
×	1557.6511	$[V\cos(\beta-\alpha)]^2$.
42	42	V.
ENT	42.	
×	1764.	V^2.
−	-206.3489	$[V\cos(\beta-\alpha)]^2 - V^2$.
140	140	TAS.
ENT	140.	
×	19600.	TAS^2.
+	19393.652	$[V\cos(\beta-\alpha)]^2 - V^2 + TAS^2$.
√	139.26109	$\sqrt{[V\cos(\beta-\alpha)]^2 - V^2 + TAS^2}$.
MR	39.467089	$V\cos(\beta-\alpha)$.
+	178.72817	$V\cos(\beta-\alpha) + \sqrt{[V\cos(\beta-\alpha)]^2 - V^2 + TAS^2}$. = Predicted ground speed.

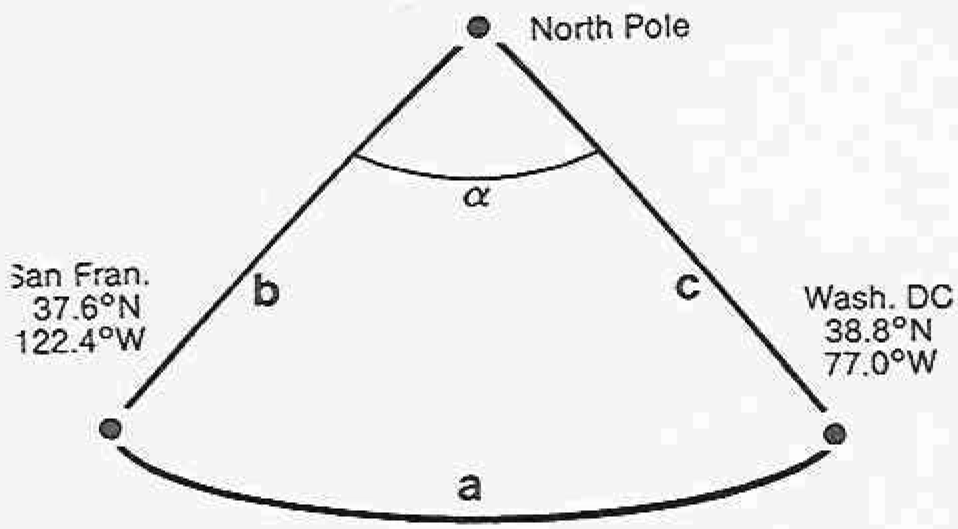
True Heading

Using the equation:

$$\sphericalangle\gamma = \alpha - \arcsin\ (V\sin(\beta-\alpha)/TAS)$$
$$= 30 - \arcsin\ (42\sin(50-30)/140)$$

KEY IN	DISPLAY SHOWS	COMMENTS
30	30	True course (α).
ENT	30.	
MS	30.	Save for further use.
42	42	Wind velocity (V).
ENT	42.	
50	50	Wind direction (β).

ENT	50.	
MR	30.	Recall α.
−	20.	
sin	0.3420203	sin $(\beta-\alpha)$.
×	17.101015	V sin $(\beta-\alpha)$.
140	140	TAS.
÷	0.1221501	V sin $(\beta-\alpha)$/TAS.
arc	0.1221501	
sin	7.0155541	arc sin [V sin $(\beta-\alpha)$/TAS].
−	34.984446°	α − arc sin [V sin $(\beta-\alpha)$/TAS]. = True heading.



What is the great circle route between San Francisco and Washington D.C.?

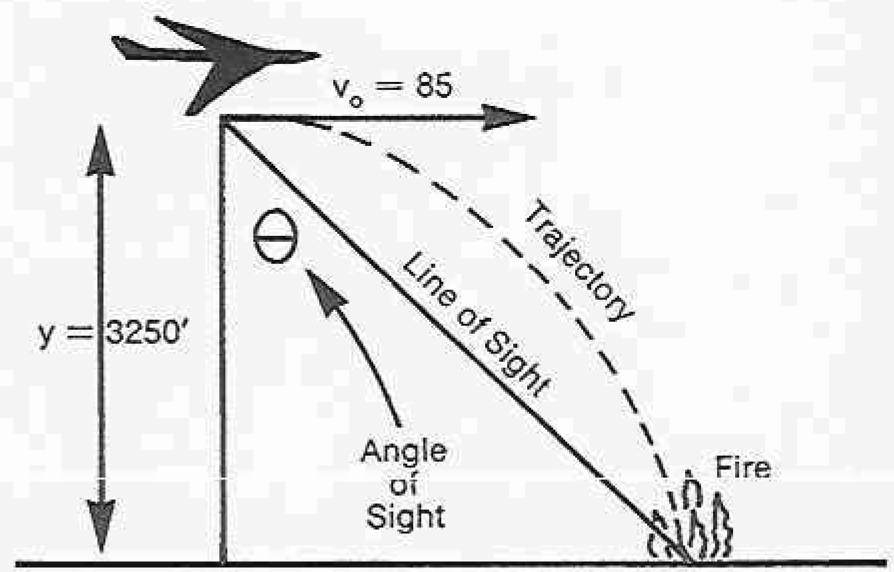
Using the formula:

$$a = \text{arc cos}(\cos b \cos c + \sin b \sin c \cos \alpha) \times 60$$

where: $\alpha = 122.4° - 77° = 45.4°$,
$b = 90° - 37.6° = 52.4°$, and
$c = 90° - 38.8° = 51.2°$.

$$a = \text{arc cos}(\cos 52.4 \cos 51.2 + \sin 52.4 \sin 51.2 \cos 45.4) \times 60.$$

KEY IN	DISPLAY SHOWS	COMMENTS
52.4	52.4	b.
cos	0.6101454	cos b.
51.2	51.2	c.
cos	0.6266041	cos c.
×	0.3823196	cos b cos c.
52.4	52.4	b.
sin	0.7922894	sin b.
51.2	51.2	c.
sin	0.7793377	sin c.
×	0.6174609	sin b sin c.
45.4	45.4	α.
cos	0.7021533	cos α.
×	0.4335522	sin b sin c cos α.
+	0.8158718	cos b cos c + sin b sin c cos α.
arc	0.8158718	
cos	35.326047	arc cos (cos b cos c + sin b sin c cos α).
60	60	
×	2119.5628	Great circle distance.



Calculate the angle of sight Θ that chemical retardant should be dropped from a fire-fighting plane to reach the fire if the plane is at 3250 feet with a velocity of 85 mph? Using the formula:

$$\theta = \tan^{-1} \frac{v_o t}{y}$$

Where: θ = angle of sight,
v_o = velocity of the plane,
y = altitude of the plane,
t = time of fall for the retardant.

Time of fall for the retardant can be calculated using the formula:

$$t = \sqrt{2y/g}$$

Where: g = force of gravity = 32 ft/sec².

KEY IN	DISPLAY SHOWS	COMMENTS
2	2	Calculate t first.
ENT	2.	
3250	3250	Altitude of the plane.
MS	3250.	Store for use in calculating θ.
×	6500.	
32	32	Force of gravity.
÷	203.125	
√	14.252192	$t = \sqrt{2y/g}$ calculated.
85	85	Velocity of the plane.
ENT	85.	
5280	5280	Feet/mile.
×	448800.	
3600	3600	Seconds/hour.
÷	124.66666	Speed expressed as ft/sec.
×	1776.7731	$v_o t$.
MR	3250	Recall altitude.
÷	0.5466994	$v_o t/y$.
arc tan	28.665174	Angle of sight θ.

FINANCE

What will $7,000 be worth in five years if it is compounded annually at a rate of 8.2% per year?

Using the formula: $FV = PV(1 + i)^n$

where: FV = future value,
PV = present value,
i = interest per period (in decimal),
n = number of periods.

$$= 7000\,(1 + .082)^5$$

KEY IN	DISPLAY SHOWS	COMMENTS
1	1	
ENT	1.	
.082	0.082	i.
+	1.082	
5	5	n.
y^x	1.4829825	$(1 + i)^n$.
7000	7000	PV.
×	10380.877	Future value (FV).

Compute the annual rate of return (after taxes) of an investment of $10,000 which, after 3½ years is worth $12,550 if the tax rate is 38%.

Using the formula:

$$r = \frac{(FV - PV)\,(1 - \text{tax rate})}{PV} \times n$$

Where: r = rate of return,
FV = future value,
PV = present value,
n = number of periods.

KEY IN	DISPLAY SHOWS	COMMENTS
12550	12550	FV.
ENT	12550.	
10000	10000	PV.
MS	10000.	Save for use in dividing.
−	2550.	FV − PV.

1	1	
ENT	1.	
.38	0.38	Tax rate.
−	0.62	1 − tax rate.
×	1581.	(FV − PV) (1 − tax rate).
MR	10000.	Recall PV.
÷	0.1581	(FV − PV) (1 − tax rate)/PV.
3.5	3.5	n.
×	0.55335	(FV − PV) (1 − tax rate)/PV x n.
100	100	
×	55.335	Multiply by 100 to make into whole percentage, = rate of return.

Part 1.
What is the annual payment on a loan of $86,000 taken for 10 years if the rate is 8% per year?

Using the formula:

$$PMT = PV\left[\frac{i}{1-(1+i)^{-n}}\right]$$

where: PMT = payment,
PV = present value,
i = interest rate per period (in decimal),
n = number of periods.

KEY IN	DISPLAY SHOWS	COMMENTS
1	1	
ENT	1.	
.08	0.08	i.
+	1.08	(1 + i).
10	10	n.
CHS	−10	
y^x	0.4631938	$(1 + i)^{-n}$.
CHS	−0.4631938	
1	1	
+	0.5368062	$1 - (1 + i)^{-n}$.
.08	0.08	i.
x–y	0.5368062	
÷	0.1490295	$i/1 - (1 + i)^{-n}$.
86000	86000	PV.
×	12816.537	PMT.

See Appendix B — Part 4 for a stack diagram of this example.

Part 2.
In the above example (part 1), what is the remaining balance after the sixth payment?

Using the formula:

$$BAL_k = PMT\left[\frac{1-(1+i)^{k-n}}{i}\right]$$

Where: k = number of payments made.

KEY IN	DISPLAY SHOWS	COMMENTS
1	1	
ENT	1.	
.08	0.08	i.
MS	8. −02	Store for further use.
+	1.08	1 + i.
6	6	k.
ENT	6.	
10	10	n.
−	−4.	k − n.
y^x	0.7350301	$(1 + i)^{k-n}$.
CHS	−0.7350301	
1	1	
+	0.2649699	$1 - (1 + i)^{k-n}$.
MR	8. −02	Recall i.
÷	3.312123	$1 - (1 + i)^{k-n}/i$.
12816.55	12816.55	PMT (from Part 1).
×	42449.99	Bal_k.

Appendix B — Part 2
Hyperbolic and Inverse Hyperbolic Functions

The hyperbolic and inverse hyperbolic functions can be found by using the Gudermannian function:

$\text{gd}\, x = 2 \arctan e^x - \pi/2$ (Note: $\pi/2 = 90°$).

and the inverse Gudermannian function:

$\text{gd}^{-1} x = \ln \tan [\pi/4 + x/2]$ (Note: $\pi/4 = 45°$).

in conjunction with the following formulas:

$$\sinh x = \frac{e^x - e^{-x}}{2},$$

$$\sinh^{-1} x = \ln [x + \sqrt{(x^2 + 1)}] = \text{gd}^{-1} (\sin^{-1} x),$$

$$\cosh x = \frac{e^x + e^{-x}}{2},$$

$$\cosh^{-1} x = \text{sech}^{-1} 1/x,$$

$$\tanh x = \frac{\sinh x}{\cosh x} = \sin \text{gd}\, x,$$

$$\tanh^{-1} x = \tfrac{1}{2} \ln [1 + x/1 - x] = \text{gd}^{-1} (\sin^{-1} x),$$

$$\coth x = \frac{1}{\tanh x},$$

$$\coth^{-1} x = \tanh^{-1} 1/x,$$

$$\text{sech}\, x = \frac{1}{\cosh x},$$

$$\text{sech}^{-1} x = [\ln 1/x + \sqrt{1/x^2 - 1}] = \text{gd}^{-1} (\cos^{-1} x),$$

$$\text{csch}\, x = \frac{1}{\sinh x}$$

$$\text{csch}^{-1} x = \sinh^{-1} 1/x.$$

Examples:

Gudermannian function: gd 0.225 = 12.78301
Key in: .225 [eˣ] [arc] [tan] 2 [×] 90 [−]
Display shows: 12.78301

Inverse Gudermannian function: gd^{-1} 60° = 1.3169571
Key in: 60 [ENT] 2 [÷] 45 [+] [tan] [ln]
Display shows: 1.3169571

Hyperbolic sine: sinh 2.5 = 6.050203
Key in: 2.5 [eˣ] [ENT] [1/x] [−] 2 [÷]
Display shows: 6.050203

See Appendix B — Part 4 for a stack diagram of this example.

Hyperbolic cosine: cosh 2.5 = 6.132288
Key in: 2.5 [eˣ] [ENT] [1/x] [+] 2 [÷]
Display shows: 6.132288

Hyperbolic tangent: tanh 2.5 = 0.9866173
Key in: 2.5 [eˣ] [arc] [tan] 2 [×] 90 [−] [sin]
Display shows: 0.9866173

Hyperbolic cotangent: coth 2.5 = 1.013564
Key in: 2.5 [eˣ] [arc] [tan] 2 [×] 90 [−] [sin] [1/x]
Display shows: 1.013564

Hyperbolic secant: sech 2.5 = 0.1630712
Key in: 2.5 [eˣ] [ENT] [1/x] [+] 2 [÷] [1/x]
Display shows: 0.1630712

Hyperbolic cosecant: csch 2.5 = 0.1652837
Key in: 2.5 [eˣ] [ENT] [1/x] [−] 2 [÷] [1/x]
Display shows: 0.1652837

Inverse hyperbolic sine: $\sinh^{-1}$ 30 = 4.0947481
Key in: 30 [arc] [tan] 2 [÷] 45 [+] [tan] [ln]
Display shows: 4.0947481

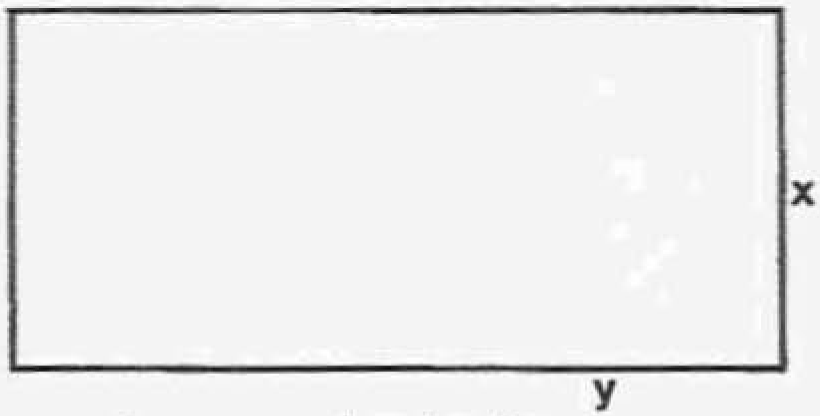
Inverse hyperbolic tangent: $\tanh^{-1}$ .52 = 0.5763266
Key in: .52 [arc] [sin] 2 [÷] 45 [+] [tan] [ln]
Display shows: 0.5763266

Inverse hyperbolic secant: sech^{-1} .52 = 1.2713823
Key in: .52 [arc] [cos] 2 [÷] 45 [+] [tan] [ln]
Display shows: 1.2713823

Inverse hyperbolic cosine: $\cosh^{-1}$ 30 = 4.0941957
Key in: 30 [1/x] [arc] [cos] 2 [÷] 45 [+] [tan] [ln]
Display shows: 4.0941957

Inverse hyperbolic cotangent: $\coth^{-1}$ 30=3.334028 −02
Key in: 30 [1/x] [arc] [sin] 2 [÷] 45 [+] [tan] [ln]
Display shows: 3.334028 −02

Inverse hyperbolic cosecant: csch^{-1} .52 = 1.4086939
Key in: .52 [1/x] [arc] [tan] 2 [÷] 45 [+] [tan] [ln]
Display shows: 1.4086939



Rectangle, area and perimeter

Rectangle of width X and length Y

Area = XY

Perimeter = 2X + 2Y

Example: Rectangle of width 4 and length 8:

Area: Key in: 4 ENT 8 ×
Display shows: 32.

Perimeter: Key in: 2 ENT 4 × 2 ENT 8 × +
Display shows: 24.

Circle, area and circumference

Circle of radius r.

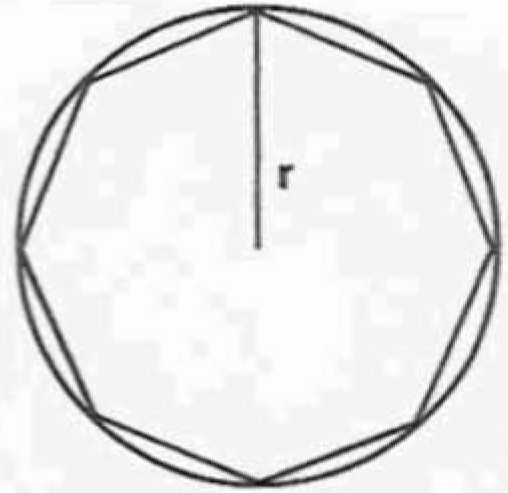
Area = πr^2

Circumference = $2\pi r$

Example: Circle of radius 5.

Area: Key in: π ENT 5 ENT × ×
Display shows: 78.539817

Circumference: Key in: 2 ENT π × 5 ×
Display shows: 31.415927



Regular polygon circumscribed in a circle, area and perimeter

Regular polygon with n sides circumscribed in a circle of radius r.

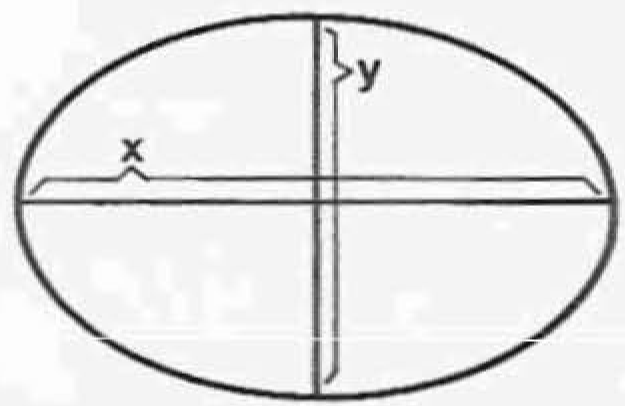
Area = $\frac{1}{2} nr^2 \sin 360/n$

Perimeter = 2nr sin 180/n

Example: Polygon with 8 sides inscribed in a circle of radius 5.

Area: Key in: 1 ENT 2 ÷ 8 × 5 ENT × × 360 ENT 8 ÷ sin ×
Display shows: 70.71064

Perimeter: Key in: 2 ENT 8 × 5 × 180 ENT 8 ÷ sin ×
Display shows: 30.614688



Ellipse, area and circumference

Ellipse of major axis X and minor axis Y.

Area = $\frac{1}{4}\pi XY$

Circumference =
$2\pi\sqrt{1/8(X^2 + Y^2)}$

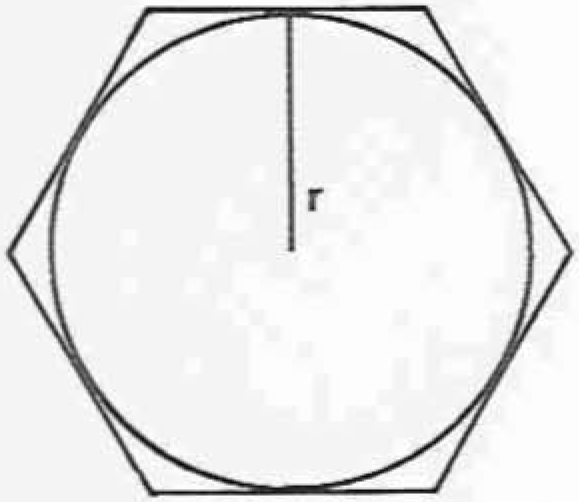
Example: Ellipse of major axis 8 and minor axis 4.

Area: Key in: 1 ENT 4 ÷ π × 8 × 4 ×

Display shows: 25.132739

Circumference: Key in: 1 ENT 8 ÷ 8 ENT × 4 ENT × + × √ 2 × π ×

Display shows: 19.869172



Regular polygon circumscribing a circle, area and perimeter

Regular polygon with n sides circumscribing a circle of radius 5.

Area $= nr^2 \tan 180/n$

Perimeter $= 2nr \tan 180/n$

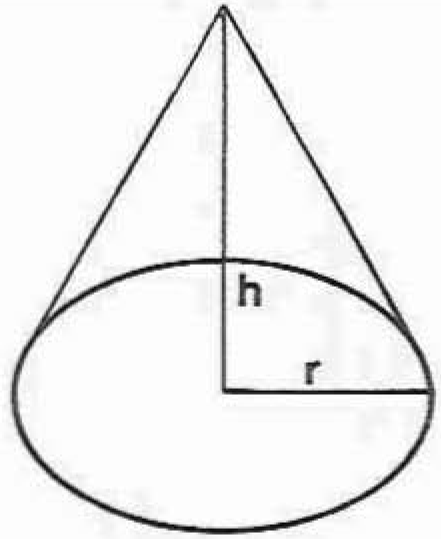
Example: Polygon with 8 sides circumscribing a circle of radius 5.

Area: Key in: 8 ENT 5 ENT × × 180 ENT 8 ÷ sin ×

Display shows: 76.53672

Perimeter: Key in: 2 ENT 8 × 5 × 180 ENT 8 ÷ tan ×

Display shows: 33.137096



Cone, area and volume

Cone of radius r and height h

Volume $= \frac{1}{3}\pi r^2 h$

Area $= \pi r\sqrt{r^2 + h^2}$

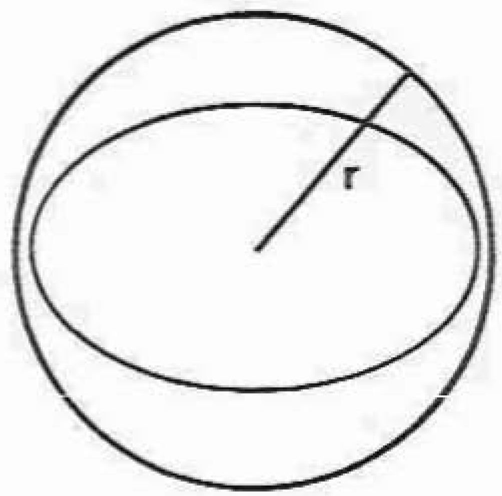
Example: Cone of radius 5 and height 10.

Volume: Key in: 1 ENT 3 ÷ π × 5 ENT × × 10 ×

Display shows: 261.79935

Area: Key in: π ENT 5 MS × MR ENT × 10 ENT × + √ ×

Display shows: 175.62035



Sphere, area and volume

Sphere of radius r.

Volume $= 4/3\pi r^3$

Area $= 4\pi r^2$

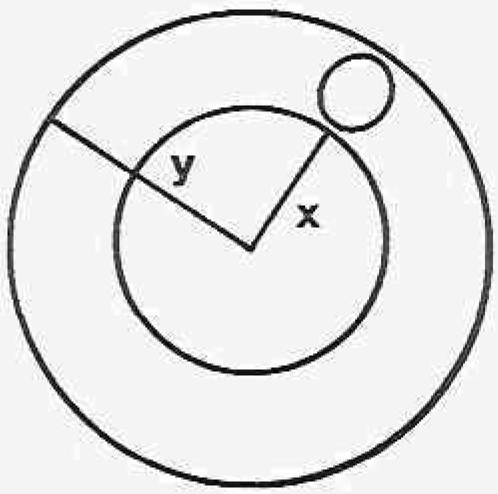
Example: Sphere of radius 5.

Volume: Key in: 5 ENT 3 y^x π × 4 ENT 3 ÷ ×

Display shows: 523.59809

Area: Key in: 4 ENT π × 5 ENT × ×

Display shows: 314.15925



Torus, area and volume

Torus of inner radius x and outer radius y.

Volume $= \frac{1}{4}\pi^2 (x+y)(y-x)^2$

Area $= \pi^2(y^2-x^2)$

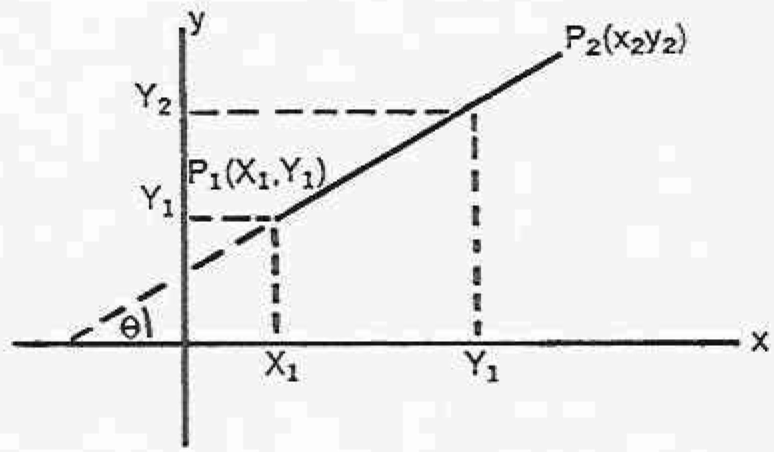
Example: Torus with inner radius 2 and outer radius 4.

Volume: Key in: 1 ENT 4 ÷ π ENT × × 2 ENT 4 + 4 ENT 2 − ENT × × ×

Display shows: 59.217626

Area: Key in: π ENT × 4 ENT × 2 ENT × − ×

Display shows: 118.43525



Distance between two points, P_1 and P_2

Distance d between two points $P_1(x_1y_1)$ and $P_2(x_2y_2)$.

$d = \sqrt{(x_2-x_1)^2 + (y_2-y_1)^2}$

Example: Distance between points $P_1(3,4)$ and $P_2(5,8)$.

Key in: 5 ENT 3 − ENT × 8 ENT 4 − ENT × + √

Display shows: 4.472135

Slope and angle of line between points

Slope and angle of line between points P_1 and P_2.

Slope $= m = y_2-y_1/x_2-x_1 = \tan \Theta$

Example: Slope: Key in: 8 ENT 4 − 5 ENT 3 − ÷

Display shows: 2.

Angle: Key in: arc tan

Display shows: 63.434781°

Appendix B — Part 4
Stack Diagrams for Some Examples

STACK DIAGRAM FOR: X=R COS Θ, Y=R SIN Θ

REGISTER CONTENTS																
M				R	R	R	R	R	R	R	R	R	R			
T								R				R				
Z						R	R	Θ	R	R	R	R COS Θ	R			
Y		Θ	Θ	Θ	R	Θ	Θ	COS Θ	Θ	R COS Θ	R COS Θ	SIN Θ	R COS Θ			
X	Θ	Θ	R	R	Θ	Θ	COS Θ	R	X = R COS Θ	Θ	SIN Θ	R	Y=R SIN Θ			
KEY IN	Θ	ENT	R	MS	X-Y	ENT	COS	MR	X	X-Y	SIN	MR	X			

STACK DIAGRAM FOR $PMT = PV \left[\frac{i}{1-(1+i)^{-n}} \right]$

REGISTER CONTENTS																
M																
T																
Z																
Y		1	1		1+i	1+i			$-(1+i)^{-n}$		$1-(1+i)^{-n}$	i		$\frac{i}{1-(1+i)^{-n}}$		
X	1	1	i	1+i	n	-n	$(1+i)^{-n}$	$-(1+i)^{-n}$	1	$1-(1+i)^{-n}$	i	$1-(1+i)^{-n}$	$\frac{i}{1-(1+i)^{-n}}$	PV	$PV \left[\frac{i}{1-(1+i)^{-n}}\right]$	
KEY IN	1	ENT	i	+	n	CHS	Y^X	CHS	1	+	i	x-y	÷	PV	X	

STACK DIAGRAM FOR SINH $X = \frac{e^x - e^{-x}}{2}$

REGISTER CONTENTS																
M																
T																
Z																
Y			e^x	e^x		$e^x - e^{-x}$										
X	X	e^x	e^x	e^{-x}	$e^x - e^{-x}$	2	$\frac{e^x - e^{-x}}{2}$									
KEY IN	X	e^x	ENT	$\frac{1}{x}$	−	2	÷									

STACK DIAGRAM OF $R = \sqrt{x^2 + y^2}$ AND $\Theta = \text{ARC TAN } \frac{y}{x}$

REGISTER CONTENTS																
M						Y	Y	Y	Y	Y	Y					
T							X									
Z			X		X	X	X^2	X				$\sqrt{x^2+y^2}$	$\sqrt{x^2+y^2}$			
Y		X	X	X	X^2	X^2	Y	X^2	X	X	$\sqrt{x^2+y^2}$	X	Y	$\sqrt{x^2+y^2}$	$\sqrt{x^2+y^2}$	
X	X	X	X	X^2	Y	Y	Y	Y^2	x^2+y^2	$\sqrt{x^2+y^2}$	X	Y	X	$\frac{y}{x}$	$\frac{y}{x}$	$\text{TAN}^{-1}\frac{y}{x}$
KEY IN	X	ENT	ENT	X	Y	MS	ENT	X	+	$\sqrt{\ }$	x-y	MR	x-y	÷	ARC	TAN

Table 1: Conditions for Error Indication

FUNCTION	CONDITION (x = contents of register X)
÷ or 1/x	$\lvert x\rvert = 0$
y^x	$y < 0$ $x \log y > 99$
e^x	$\lvert x\rvert > 99$
10^x	$\lvert x\rvert > 99$
log x or ln x	$x \leqslant 0$
sin x, cos x, tan x	$x < 0$ or $x > 90$
arc sin x or arc cos x	$x < 0$ or $x > 1$
arc tan x	$x < 0$
Program loading	Loading more than 100 steps

Table 2: Range and Accuracy of Functions

FUNCTION	RANGE
=, −, ×, ÷, 1/x	$\pm 1 \times 10^{-99} \leqslant x \leqslant \pm 9.9999999 \times 10^{99}$
x	$\pm 1 \times 10^{-99} \leqslant x \leqslant \pm 9.9999999 \times 10^{99}$
log x	$0 < x \leqslant +9.9999999 \times 10^{99}$
ln x	$0 < x \leqslant +9.9999999 \times 10^{99}$
10^x	$\pm 1 \times 10^{-99} \leqslant x \leqslant +99$
e^x	$\pm 1 \times 10^{-99} \leqslant x \leqslant +99$
y^x	$y > 0$
sin, cos, tan	$0° \leqslant x < +90°$
arc sin, arc cos	$0 \leqslant x \leqslant +1$
arc tan	$0 \leqslant x \leqslant 9.9999999 \times 10^{99}$

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Other "professional" calculators from NOVUS...

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The Electronic Slide Rule
- Trig and inverse trig functions
- Common and natural logs and anti-logs
- Fully addressable, accumulating memory

Novus 4515 Mathematician PR

The Programmable Electronic Slide Rule
- Same features as Novus 4510
- 100-step programming capability

Novus 4520 Scientist

The Scientist's Electronic Slide Rule
- Scientific notation
- Trig and inverse trig functions
- Common and natural logs and anti-logs

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- 100-step programming capability

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NOVUS, the consumer products division of National Semiconductor Corporation, is proud to guarantee your electronic calculator to be free from defects in workmanship and materials for a period of one year from the date of your purchase. Defects caused by abuse, accidents, modifications, negligence, misuse or other causes beyond the control of NOVUS are, of course, not covered by this warranty, nor are batteries. Should the calculator prove defective within 30 days of purchase, NOVUS will repair or, at its discretion, replace it free of charge. If the defect occurs after 30 days from date of purchase, a charge of $3.50 will be made for handling and insurance. If your calculator becomes defective after the one-year period, NOVUS will make repairs for a nominal charge of $20.00. Simply mail it prepaid and insured with your check or money order to the nearest NOVUS service center. Repair prices are subject to change without notice. Please do not send or include cash. Make your check or money order payable to NOVUS. Upon receipt, your calculator will be promptly serviced and returned to you freight prepaid.

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Please put your warranty into effect by completing this form and mailing it within 10 days from date of purchase to the NOVUS service center in your area.

Novus Model 4525

Serial Number 112988

Purchase Date 6/29/76
(month/day/year)

Purchased from SIMPSONS-SEARS, ST. LAURENT SHOPPING CENTRE, OTTAWA, ONT.

Address ST. LAURENT BLVD. OTTAWA, ONT.

City, State, Zip OTTAWA, ONT.

Your Name W.C. BROWN

Your Address 18 DAVIDSON DR., OTTAWA, ONT.

City, State, Zip OTTAWA, ONT.

Optional Information

Was this calculator purchased for:
- ☐ Gift ☑ Personal use

What is your occupation?
- ☐ Student or Teacher ☐ Professional
- ☐ Executive ☐ Financial or Commercial
- ☐ Engineering or Scientific ☐ Statistical fields
- ☐ Other occupation ____________

What is your age group?
- ☐ Under 18 ☐ 18-34 ☐ 35-49 ☐ 50-over

Where will you most use your Novus calculator?
- ☐ At home ☐ At school ☐ At work
- ☐ During travel

Where did you learn about the Novus calculators?
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- ☐ Radio ☐ Mail ☐ Store salesman
- ☐ Friend
- ☐ Other ____________

What most attracted you to your Novus calculator?
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- ☐ Price ☐ Features and capabilities

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NOVUS Warranty Certificate
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Model Number 4525

Serial Number 112988

Purchased from SIMPSONS-SEARS ST. LAURENT

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